January 5, 1959

Aviation Week

Including Space Technology

75 Cents

A McGraw-Hill Publication

Thiokol Stresses Research On Rocket Motors

Hiller X-18 VTOL

USAF Tests Synthetic Hydraulic Fluids

AVIATION CALENDAR

Jan. 12-14—Fifth National Symposium on Reliability and Quality Control in Electronics, Bellevue Statler Hotel, Phila.

Jan. 12-16—1959 Annual Meeting and Engineering Display, Society of Automotive Engineers, Sheraton Cadillac and Statler Hotel, Detroit, Mich. Dr. T. Keith Glennan, speaker, SAE Dinner, Jan. 14.

Jan. 13-14—Symposium on Cathode Ray Tube Recording, sponsored by Systems Development Corp., Engineers Club, Dayton, Ohio.

Jan. 19-21—11th Annual Convention, Helicopter Assn. of America, Villa Hotel, San Mateo, Calif.

Jan. 21-23—South West Electronic Exhibit, Arizona State Fairgrounds, Phoenix, Ariz.

Jan. 26-27—Annual Meeting, Assn. of Local and Territorial Airlines, National Aviation Club, Washington, D. C.

Jan. 26-29—27th Annual Meeting, Institute of the Aeronautical Sciences, Sheraton-Astor Hotel, New York, N. Y. Honors Night Dinner, Jan. 27.

Jan. 27-29—Fifth Annual Radar Symposium (classified), Rackham Bldg., University of Michigan, Ann Arbor, Mich.

Jan. 27-30—15th Annual Technical Conference, Society of Plastics Engineers, Hotel Commodore, New York, N. Y.

Jan. 28-29—Fifth Annual Midwest Welding Conference, sponsored by Armour Research Foundation, Illinois Institute of Technology, Chicago, Ill.

Feb. 3-5—14th Annual Technical and Management Conference, Reinforced Plastics Division, Society of the Plastics Industry, Inc., Edgewater Beach Hotel, Chicago.

Feb. 12-13—1959 Solid State Circuits Conference, sponsored by Institute of Radio Engineers' Professional Group on Circuit Theory, American Institute of Electrical Engineers' Committee on Electronics and

(Continued on page 6)

AVIATION WEEK Including Space Technology

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AVIATION CALENDAR

(Continued from page 5)

University of Pennsylvania, Philadelphia

Feb. 12-13—Computer and Data Processing in Industry conference for manufacturing and engineering management, Purdue University, Lafayette, Ind.

Feb. 14—Meeting on Short Range Navigational Aids, International Civil Aviation Organization, International Aviation Bldg., Montreal, Canada.

Feb. 21-22—13th Annual Pacific Coast Mid-Winter Soaring Championships, Torrey Pines Gliderport, San Diego, Calif.

Feb. 26-March 1—1959 Engineering Exposition, Balboa Park, San Diego, Calif. Address inquiries to 422 Land Title Bldg., San Diego, Calif.

March 3-5—1959 Western Joint Computer Conference, sponsored by Institute of Radio Engineers, American Institute of Electrical Engineers and Assn. for Computing Machinery, Fairmont Hotel, San Francisco, Calif.

March 5-6—Flight Propulsion Meeting (classified), Institute of the Aeronautical Sciences, Hotel Carter, Cleveland, Ohio.

March 5-7—Western Space Age Conference and Exhibit. For information: Domestic Trade Dept., Los Angeles Chamber of Commerce, 404 South Bixel St., Los Angeles 54, Calif.

March 8-11—Engineering meeting on the turbine in action, sponsored by Gas Turbine Division of the American Society of Mechanical Engineers, Cincinnati, Ohio.

March 16-20—11th Western Metal Exposition and Congress, American Society for Metals, Pan Pacific Auditorium and Ambassador Hotel, Los Angeles, Calif.

March 23-26—National Convention, Institute of Radio Engineers, Coliseum and Waldorf Astoria Hotel, New York, N. Y.

March 31-Apr. 2—Polytechnic Institute of Brooklyn's Ninth International Symposium, Subject: Millimeter Waves, Auditorium, Engineering Societies Bldg., New York, N. Y. Cosponsors: Department of Defense Research Agencies and Institute of Radio Engineers.

March 31-Apr. 3—National Aeronautic Meeting, Society of Automotive Engineers, Hotel Commodore, New York, N. Y.

Apr. 5-10—1959 Nuclear Congress, Municipal Auditorium, Cleveland, Ohio. For information: Engineers Joint Council, 29 West 39th St., New York 18, N. Y.

Apr. 7-10—1959 Welding Show and 40th Annual Convention, American Welding Society, International Amphitheatre and Hotel Sherman, Chicago, Ill.

Apr. 12-19—Air Force Assn.'s World Congress of Flight, Las Vegas, Nev.

Apr. 18-22—Annual Meeting, American Society of Tool Engineers, Schroeder Hotel, Milwaukee, Wis.

Apr. 22-24—1959 Annual Meeting, Institute of Environmental Engineers, LaSalle Hotel, Chicago, Ill.

May 4-6—National Aeronautical Electronics Conference, Institute of Radio Engineers, Biltmore Hotel, Dayton, Ohio.

May 4-7—Fifth Annual Flight Test Instrumentation Symposium, sponsored by the Instrument Society of America, Seattle Section, Olympic Hotel, Seattle, Wash.

A thermometer reading?

Internal motion
of body particles?

What is absolute zero?

What happened to the
3rd law of thermodynamics?

How is temperature defined
in the "pinch effect"?

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COVER Hiller X-18 vertical takeoff and land aircraft will start its flight test program early this year with engine runups and liftoffs. Final testing will be at Edwards AFB, Calif. Aircraft is powered by two Allison T40A-14 turboprop engines producing 5,535 eshp each (AW Dec. 15, p. 34). Contra-rotating propellers are Curtiss-Wright turboelectric units from Navy Pogo VTOL program.

PICTURE CREDITS

COVER—Hiller; 18—Lockheed; 21—U. S. Navy; 23—Aviation Week; 25, 37—Wide World; 26, 66, 67, 95—USAF; 32—Northwest Orient Airlines; 42, 43, 45—Thiokol Chemical Corp.; 50—(top) Rocketdyne (bottom) Boeing; 55, 57—Rolls-Royce Ltd.; 71—Erwin J. Bulban; 94—Sperry Gyroscope Co.

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Killian's White House Role

(The responsibilities and scope of the office of the special assistant to the President for science and technology have remained obscure since the post was created in the post-Sputnik fall of 1957 when Dr. James R. Killian, then president of the Massachusetts Institute of Technology, was summoned to Washington. Dr. Killian last week made his most comprehensive report to date on the workings of his office and of the Science Advisory Committee, which he chairmans. Because of the importance of his post and the need for a better understanding of the concepts under which it is directed, Aviation Week is reprinting below significant extracts of Dr. Killian's speech at the annual meeting of the American Assn. for Advancement of Science.)

. . . Let me . . . describe the organization and work of the President's Science Advisory Committee since it was reconstituted at the White House level and since the appointment of the special assistant to the President for science and technology.

The Committee is concerned broadly in making scientific advice and analysis available where they are needed in the formulation of national policy. It is also concerned with the effect of national policies on the nation's scientific and engineering activities.

There has been apparently a misconception abroad that my office and the Science Advisory Committee have operating responsibilities. We do not. We have no operational responsibility, for example, for the development of missiles or satellites. We have, of course, made intensive studies of various aspects of our missile and space programs for the information and use of the President. Neither do we have any responsibility to decide policy. My function and that of the Committee is to provide answers to questions raised by the President, to undertake assignments for him of an advisory kind, to mobilize the best scientific advice in the country, and make recommendations to him in regard to ways by which United States science and technology can be advanced, especially in regard to ways by which they can be advanced by the federal government and on how they can best serve the nation's security and welfare. This advisory service, the President has indicated, is available also to members of the Cabinet.

One of the principal functions of the Science Advisory Committee is to provide a communications center for science in the federal government and thus to facilitate intercommunication among various scientific activities within government and between the civilian scientific community and the government. It is important to note that the President of the National Academy of Sciences is ex-officio a member of the Committee and that the outgoing President of ICSU (International Council of Scientific Unions) has also been a member. The director of the National Science Foundation and the Science Adviser of the State Department sit with the Committee, and the director of research and engineering of the Department of Defense and the chairman of the Defense Science Board are members. Warren Weaver once observed that "What science needs is not a lot of planning, but a lot of convenient communication, so that controls may arise naturally from feedback."

The eighteen members of the Committee are representative of those fields of science and technology currently important to the government. With the exception of certain ex-officio members the regular members of the Committee have limited terms and thus the membership on the Committee rotates. Rotation of members will bring to the Committee different points of view and fields of science not hitherto represented. It will also help the Committee to avoid ever becoming inbred in its point of view.

In carrying on its work for the President, the Science Advisory Committee is organized into a group of panels which include both regular Committee members and other engineers and scientists selected from outside the ranks of the Committee. Some of these panels have standing responsibilities, others are called together for ad hoc assignments. This panel structure has been a marked characteristic of the work of the Committee, and the intensive studies made possible by the individual panels have enabled us to tackle problems which could not be effectively undertaken by the Committee itself with its limited membership. The panels are responsible to the Science Advisory Committee, but they draw into our councils a wider range of scientific experience and expert advice than can be provided by a single committee. The Committee also serves as a board of consultants to me as special assistant to the President. This relationship is highly important. One man should not try to represent science or to provide expert advice in a variety of fields. I draw upon the full range of advice and experience of the Science Advisory Committee and its panels. The Committee has the prerogative, when it chooses, to report directly to the President. As special assistant I also have, in addition to the Advisory Committee and its panels, special consultants, task forces, and staff. At the present time the Science Advisory Committee and my office have about 75 scientists and engineers serving part time.

It is important to note that the special assistant for science and technology is invited to sit in on meetings of the National Security Council and the Cabinet and when appropriate or requested, to present the views and findings of the Science Advisory Committee. The President has thus created a mechanism to bring objective scientific and engineering advice to the top levels of government in a manner that reaches across all agencies and departments and yet can serve each of them.

In creating this new post and in reconstituting the Science Advisory Committee, widening its scope and associating it with the White House, the President has given special recognition to the fact that science and technology, apart from their use in solving specific problems, have a direct and creative impact on the formulation of public policy. The reconstitution of the Committee and the establishment of my office have stimulated an extraordinary array of requests within government to make scientific advice available. The problem has been to avoid being overwhelmed by the many requests for advisory services while at the same time trying to respond helpfully and promptly whenever a need exists. The President's Committee has encouraged the strengthening and full use of each department and agency's own advisory groups.

WHO'S WHERE

In the Front Office

Dr. Mervin J. Kelly, board chairman, Bell Telephone Laboratories Inc., New York, N. Y. **Dr. James B. Fisk** succeeds Dr. Kelly as president. **Estill I. Green** succeeds Dr. Fisk as executive vice president.

John O. Crowley, vice president project management, Grand Central Rocket Co., Redlands, Calif., **H. L. Thackwell, Jr.**, senior vice president, formerly in charge of project management, has been assigned to organize a new division for advanced planning on outer space flight vehicles.

L. L. Dodge, vice president-administration, and **C. C. Dybvig**, vice president-sales, Dana Corp., Toledo, Ohio.

Honors and Elections

William Littlewood, vice president-equipment research for American Airlines, has been elected president of the Institute of the Aeronautical Sciences for 1959, succeeding **Edward C. Wells**, vice president-general manager of Boeing Airplane Co.'s Systems Management Office. Newly elected IAS vice presidents are: **Clifford C. Furnas**, chancellor of the University of Buffalo; **Clarence L. Johnson**, vice president-research and development of Lockheed Aircraft Corp.; **I. Nevin Falley**, vice president-engineering of Temco Aircraft Corp.; **Raymond C. Sebold**, vice president-engineering of Convair; **Jerome Lederer**, director of Flight Safety Foundation, was elected treasurer.

Sam Norris, president and board chairmen of the Nucleus Corporation of America Inc., has been appointed consultant to the Director of the Electronics Division of the Business and Defense Services Administration, U. S. Department of Commerce.

Brig. Gen. Benjamin S. Kelsey (USAF, ret.), has been named chairman of an Ad Hoc Advisory Panel to the Department of the Army on aviation research and development matters.

At the Honors Night Dinner of the American Astronautical Society, the Society's Flight Achievement Award was posthumously awarded to **Capt. Iven C. Kincheloe**.

Dr. Wellington H. Loh, Chance Vought staff engineer for the assistant chief engineer-technical, has been selected by The National Science Foundation as recipient of a senior post doctoral fellow award.

Changes

John M. Pearce, manager of Electronics Requirements, a newly created corporate office of The Martin Co., Baltimore, Md.

Capt. Wendell W. Snydam (USN ret.), assistant purchasing manager, Hamilton Standard Division of United Aircraft Corp., Windsor Locks, Conn.

C. Robert Gates, director of product planning, Northrop Division, Northrop Aircraft, Inc., Hawthorne, Calif.

Robert M. Hayflick, head-preliminary design section, Remfott Company, Inc., Clifton, N. J.

(Continued on page 95)

INDUSTRY OBSERVER

▶ North American Aviation Inc. has won the National Aeronautics and Space Administration competition for solid propellant transport (boost) vehicles for initial research at Wallops Island, Va., on full scale model capsules in connection with NASA's project Mercury manned satellite program (AW Dec. 15, p. 26). Contract for seven vehicles—six boost units and one type approved vehicle—will run approximately $800,000.

▶ Boeing Airplane Co. design in Air Force's Dyna-Soar orbital bomber competition utilizes a two-stage solid propellant booster system 35 ft. in diameter with rocket clusters in each stage. Wingspan of the final aerodynamic vehicle is 35 ft. Vertical stabilizer is used on each wing tip. Wing features sharp-sweep delta configuration. Structural proposal calls for combined use of cooling fluid in tubes bonded to external skin, a layer of insulation, then a primary, heavy load carrying substructure.

▶ Air Force decision is expected shortly on the choice of a contractor to develop a Mach 3 drone to be used as a target by North American F-108 interceptors. Bidders include the Firestone Missile Division, United Aircraft Northrop's Radioplane Division and a team consisting of Sperry Gyroscope Co. and Grumman Aircraft. Sperry and Grumman also are expected to bid as a team in a new Army target drone competition.

▶ Allegany Ballistic Laboratory is developing a lightweight second stage rocket for Navy's Polaris fleet ballistic missile using plastic motor casing and nozzles and a high energy solid propellant fuel. Weight saving aspect of this development makes it competitive with the Aerojet second stage now scheduled for the Polaris.

▶ General Electric Company's Aircraft Gas Turbine Division is exploring the possibility of obtaining an Avro CF-105 twin-jet, all-weather fighter airframe for use as a flying test bed for its J93 turbojet engines following the failure of negotiations with Air Force to get a Convair B-58 for this purpose. Development versions of the CF-105 have been flying with the Pratt & Whitney J75 and are scheduled soon to begin flight tests with a twin Orenda Iroquois turbojet installation.

▶ Companies associated with Boeing Airplane Co. in its proposal for an Air Force early warning and control aircraft include Thompson-Ramo-Wooldridge Inc., electronics, and Litton Industries, display equipment.

▶ Convair's San Diego division has formed a new missile predesign group that will project weapons for possible Air Force, Army and Navy application. New group functions outside of Convair's Astronautics Division.

▶ Some of the ground and flight test phases of the Air Force-Martin Titan ICBM are being telescoped to accelerate initial firings of the missile. Bypassed phases will be fed into the test program at a later date for a complete wringout.

▶ German Air Force version of the Lockheed F-104 interceptor will have a more sophisticated fire control system than that of the USAF version. North American Aviation's Autonetics Division will supply the major portion of this avionics gear.

▶ Launching space for engines with thrusts considerably higher than the currently planned 1-1,500,000 lb. has been reserved at Air Force Missile Test Center's Cape Canaveral, Fla., launching complex. Space also has been set aside for the 1-1,500,000 lb. thrust vehicles.

▶ Forty-inch telescope placed in a satellite orbiting at 500 mi. probably could define objects on earth of less than two ft. in size. A 200-in. telescope orbiting at about 22,000 mi. could define objects of 17 ft. in diameter. Such systems are being considered both for astronomical observation of the universe and for possible missile attack warning systems.

Washington Roundup

Traffic Headaches

Civil Aeronautics Administration, in being absorbed by the Federal Aviation Agency last week (see page 30), brought with it a steadily increasing air traffic problem that continued to overtax existing aviation facilities. New records in civil air operations were established during CAA's 20th and final year that emphasized the need for an accelerated program in air traffic control and air navigation by the Federal Aviation Agency during 1959.

Landings and takeoffs during the year, exclusive of military operations, reached a new high of 26.7 million, and fix postings jumped 17% to 35 million. Instrument flight rule en route operations climbed 23% and IFR departures rose 12% during the year. Meanwhile, the number of scheduled airline aircraft in operation declined 1%, although the total number of U.S. active aircraft rose 8%.

In an effort to cope with the increasing traffic, CAA last year purchased over $77 million worth of new equipment and established three positive control transcontinental airways. Radar installations were increased from 45 airport surveillance radars and four long-range radars to 47 ASRs and 19 long-range radars.

Small Business Contracts

Small firms received at least $14 billion—or over a third—of the total of $40 billion in military procurement during the past two fiscal years, Department of Defense reported last week.

Here's the breakdown given by the Department:

- **Small firms received $3.73 billion** in prime contract awards in Fiscal 1958 as compared with $3.78 billion in Fiscal 1957.
- **A total of 286 prime contractors** reported $3.24 billion in subcontracts to small firms in Fiscal 1958. In Fiscal 1957, 298 prime contractors reported $3.56 billion in subcontracts to small firms.

Military Property

The three military services have spent a total $26.9 billion in real property—$20.7 billion in the continental U.S. and $6.2 billion overseas, an inventory survey by House Government Operations Committee shows. Air Force has the biggest total investment ($9.5 billion) and the biggest overseas investment in territories and friendly countries ($3.4 billion).

Government Ethics

Over 50 measures relating to the ethics of government employes and outsiders dealing with the government were presented in the last session of Congress, indicating a growing interest in the subject, according to a study by the staff of the House Judiciary Committee. Two proposals to monitor the ethics were rejected by the staff as "unduly onerous and expensive in comparison to the benefits ... expected to follow." They were compulsory disclosure of income and financial interests of all public employes and mandatory preclearance by the agency or department head of all outside employment.

Congress, however, was urged to establish a uniform government-wide code of ethics which would:

- **Permanently ban** any ex-employe or retired military officers from participating in (or in the preparation of) any contract or other proceeding with the government if he acquired information on the subject matter during his government service.
- **Ban, for two years,** any ex-employe from participating in any matter whatsoever involving the agency with which he was formerly employed.
- **Prohibit those dealing with the government** "from making gifts to, discussing future employment of, or becoming unduly involved socially with officers or employes who transact government business with them, from persuading government officials and employes to divulge confidential information, from unethically employing former officers or employes as representatives, and from making ex parte representations to agency members or employes regarding the issues in contested cases that have been assigned for hearing."

Trained Manpower Shortage

President's Committee on Scientists and Engineers recommended to President Eisenhower last week that he take the "responsibility for coordinating and stimulating the nation's efforts in the development and utilization of highly trained manpower." The committee pointed out that the U.S. is in serious danger of running short of trained manpower during the 1960s. It also stressed that the Soviet program to produce competent engineering and scientific personnel is growing and has become the backbone of their effort to achieve technical supremacy. Conversely, in the U.S., freshman enrollment in engineering colleges dropped 13% in 1958. One of the physical sciences that is receiving little consideration from today's students is metallurgy. Eight metallurgists were graduated in this country in 1957. This group is differentiated from metallurgical engineers, of which there were 577 graduates during the year, because the education of a metallurgist is orientated more towards a career in basic research.

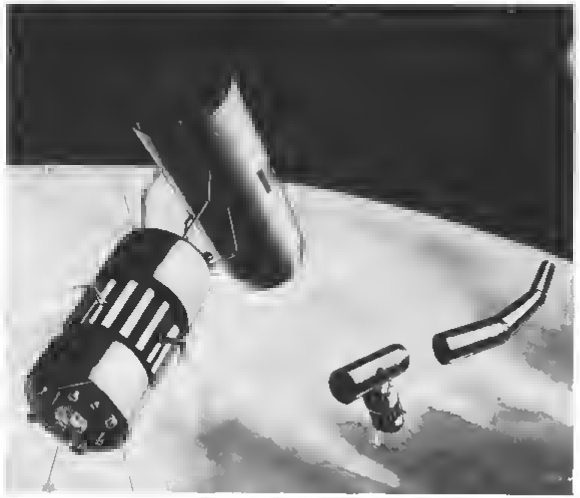
Siesta Seat Battle

Trans World Airlines' siesta sleeper seat service remains a competitive bone of contention with United Airlines. Ordered by the Civil Aeronautics Board to either drop the service or increase the fare charged by 20% by Dec. 10 (AW Dec. 1, p. 37), TWA has countered by asking the Board for a reconsideration and stay of its November rejection, arguing that a change of sleeper seat configuration from 20 to 26 seats makes the CAB order no longer applicable. United contends that TWA is engaging in "delaying tactics" and further claims that its competitor not only failed to observe the Dec. 10 cutoff date but waited until Dec. 16 to file for reconsideration following a complaint from the CAB.

Defective Parts

In a last move before being absorbed by the Federal Aviation Agency, Civil Aeronautics Administration proposed regulations to tighten control of imports and use of foreign-made aircraft parts. In the past, CAA has often found defective parts in the U.S. not made in a country having a bilateral agreement with this country. Safety standards used in the manufacture of such parts by bilateral agreement countries generally are of a higher caliber, and CAA wants imported parts labeled with the country of origin. —Washington staff

MANNED SPACE research laboratory (top left), designed by Lockheed Missile Systems Division scientists was discussed at American Astronautical Society meeting (see p 19). Drawing shows laboratory orbiting earth at 500 mi altitude. Powered by a nuclear source shielded at the end of a boom, the laboratory could operate for 10 years. At top right is the laboratory's re-entry craft to ferry personnel. Space station booster (left) would use 1.16 million lb thrust first stage engine, four 25,000 lb. thrust jets. Second stage would use hydrogen-fluorine engine, re-entry vehicle (at top) carries four hydrazine-fluorine engines.



CYLINDRICAL space vehicle, designated "astrotug" carries personnel who assemble space laboratory components

Van Allen Defines Space Radiation Belts

Two distinct bands found by Pioneer III, Iowa scientist tells American Astronautical Society.

Washington—Existence of two distinct belts of intense radiation around the earth with a relatively low level radiation buffer between is one of the important discoveries revealed by Army's recent Pioneer III lunar probe, Dr. James Van Allen reported at the fifth annual meeting of the American Astronautical Society here last week.

This suggests that a human could safely orbit in a lightly shielded satellite at altitudes of around 6,000 mi., between the two belts, Van Allen indicated.

The first radiation belt extends from approximately 1,400 to 3,400 mi. altitude at low (near-equatorial) geo-magnetic latitudes, while the second is at an altitude of 8,000 to 12,000 mi. and extends around to higher latitudes—perhaps 50 to 60 deg.

Maximum radiation intensity appears to be the same for both belts, Van Allen reported. Peak count of 25,600 per second from two Geiger counters is equivalent to radiation intensity of 10 roentgens per hour if radiation consists primarily of electrons or about 100 roentgens per hour if protons. Peak intensity occurs at altitude of about 2,400 mi. in first belt, at around 10,000 mi. in second.

Buffer Zone

Minimum intensity in the buffer zone, which occurs at around 6,000 mi., is approximately 0.3 roentgen per hour if radiation consists of electrons. This is equivalent to maximum safe weekly dosage recommended by Atomic Energy Commission.

At an altitude of around 25,000 mi., radiation intensity has fallen off to about one-thousandth its peak value, and beyond 36,000 mi. appears to remain constant at one ten thousandth the peak value, Dr. Van Allen said.

This suggests that strength of earth's magnetic field diminishes rapidly beyond an altitude of approximately 18,500 mi. from the earth's surface, making it too weak to trap particles emanating from the sun or other sources.

Pioneer III data confirms speculation advanced several months ago by Carl McIlwain, one of Van Allen's associates at State University of Iowa, that radiation consisted of two belts instead of one as originally believed (AW Nov. 3, p. 28). New data, which gives the most complete and authoritative profile of radiation intensity yet obtained, also appears to explain discrepancies in the data obtained from several previous space probes and satellite experiments. Pioneer III provided almost continuous measurements out to its 63,580 mi. apogee and back to within 2,000 mi. of the earth, providing ideal double-check data from the same instrumentation.

More Probes Needed

Result of Pioneer III probe has whetted scientists' desire to determine whether radiation consists primarily of electrons, protons, alpha particles or other types of radiation. This will require several space probe experiments using special scintillation counters which can sort one type particle from another.

Van Allen praised the performance of the Pioneer III telemetering system developed by Jet Propulsion Laboratory, the two Geiger counters manufactured by Anton Electronic Laboratories and the ground tracking stations at Goldstone, Lake, Calif., and at Mayaguez, Puerto Rico.

The society's Space Flight Award was presented to Van Allen by Dr. Hugh L. Dryden, deputy administrator of National Aeronautics and Space Administration. Both were made fellows of the society, which has grown in the past year from a membership of 410 to 850 scientists and engineers. Corporate membership has doubled, from four to eight. The meeting was held in conjunction with the 125th annual meeting of the American Association for the Advancement of Science.

Pickering Report

Dr. William H. Pickering, director of NASA's Jet Propulsion Laboratory, gave other new details on Pioneer III's flight. He reported the apogee as 63,580 mi. instead of the 66,654 mi. reported initially (AW Dec. 15, p. 28).

De-spin mechanism, which was to slow the satellite's rotation from 400 to 6 rpm., failed to operate, Pickering said although the timer that was to trigger it did function, arming the memory circuit in the optical sensing device.

The sensing experiment was to have been a test for a trigger device that could activate a television camera in future probes, but Pickering gave no indication of its success other than to say the memory circuit was armed.

Median temperature maintained by the black and white paint overlay on the gold-covered satellite was 37C over most of the flight. Goal was to keep the temperature within 10-50C, Pickering said.

Pioneer III was not expected to come closer than seven degrees to the Puerto Rico station's horizon. When the probe's incorrect trajectory carried it to within 2.3 deg., Pickering said, "there were some anxious moments" because the station had a designed beam width of approximately plus or minus four degrees—a compromise between the effective range of the system and the angular position above the horizon. The 2.3 deg. position came as the probe was passing through "the most interesting part of the Van Allen radiation belt," but the station was able to receive continuously.

Its ability to track to its design threshold of 50,000 mi. has been proved but ability of Goldstone to track to 500,000 mi. still must be tested.

Two dozen technical papers were presented at the AAS meeting, plus a dozen by American Physiological Society members whose program was cosponsored by AAS.

Orbiting Laboratory

Research laboratory that would orbit at 500 nautical mi. or more and carry a crew of 10 scientists (p. 18) was proposed by two authors from Lockheed Missile Systems Division in a paper supported by a detailed, 155-page engineering study to which 14 others had contributed. Size of the study would have been several times that except for security and editorial considerations.

The Lockheed scientists, Saunders B. Kramer and Richard A. Byers, believe the station would be feasible at the state of the art anticipated within 10 years. They claim a number of advantages over most previous space station designs. Details include:

- Station would be a 400 ton wheel assembled from cylindrical compartment, prefabricated on the ground. Cylinders would have automatic coupling devices and air locks at each end and would be 20 ft. long by 10 ft. in diameter.
- Use of multi-manned, "astrotugs"—or space "switch engines"—plus prefabrication eliminates the need to construct the station in space in the skyscraper manner suggested in many other proposals. First few sections would be guided into close proximity by ground control before the first astrotug went aloft to pull the sections together.
- Astrotug would support two or three

men for seven days. Each cylindrical compartment also would have some degree of self-sufficiency. This eliminates even the requirement for space suits and provides the natural environment needed for productive work, the authors said.

• **Boosters for the compartments** and for re-entry vehicles would use a "plugged nozzle" first stage engine of 1.16-million lb. thrust, similar to one being developed by General Electric Co. and would be recoverable through use of four jet engines. Upper two stages would use high energy propellants.

Length would be 1,820 ft.

• **Initial crew would be an astronomer,** two physicists, a chemist-photographer, a biologist, two electronic engineers, a metallurgist-machinist and two physicians.

Technique for using an earth satellite for terrestrial navigation was proposed in a paper by Robert Etcheverry, Richard Brooks and Jack Russell of the Naval Ordnance Test Station, China Lake, Calif. The method employs a combination of celestial navigation and distance-measuring equipment techniques but requires no optical measurements.

The method assumes that the orbital position of a navigation satellite can be predicted to an accuracy of within one mile at any instant in time, providing terrestial vehicle position fixing accurate to within one mile. Satellite would be equipped with small radar transponder similar to that used in ground DME/T stations on civil airways while ships and aircraft would be equipped with an interrogator similar to present airborne DME/T sets. Time required for a vehicle signal to reach the satellite and its reply to come back would be used to determine slant range distance to the satellite.

By making two such slant-range measurements, separated by a short interval of time, two circular lines of position are obtained which intersect at two points—as in celestial navigation. Vehicle could use a directional antenna to determine which one represents its own terrestial position.

Navigation satellite, which appears well within the existing state of the art, should weigh no more than 30 to 100 lb., measure two to three feet in diameter, the NOTS scientists concluded.

A high definition television camera, especially designed for a reconnaissance satellite, has been developed by Radio Corp. of America's Astro-Electronic Products Division, RCA scientists reported. A miniature television camera is designed to take "still" pictures, store the image until it can be transmitted to earth via low-powered narrow-band radio transmitter.

Operational and environmental demands of the satellite require major change in design of vidicon tube used, compared to earth-based television cameras. Tube can be exposed to image for only a few millliseconds if picture smearing is to be avoided. This requires use of photoconductive material with higher sensitivity. In order to transmit picture over narrow-band low-power transmitter requires drastically reduced vidicon scan rate which tends to reduce the picture contrast unless special corrective techniques are employed.

RCA's satellite TV camera and associated circuitry are completely transistorized and can operate unattended under variations of light and image motion despite initial exposure to stresses of rocket launching, company scientists said.

Possibility of using infrared techniques to scan the earth's horizon in order to establish vertical reference for space vehicle re-entry control was suggested by E. J. McCartney of Sperry Gyroscope Co. Use of earth's horizon could provide a vertical reference which is completely unaffected by vehicle motions. Use of infrared scanner makes technique usable in daytime or nighttime, McCartney pointed out.

Soviet ICBM Plans Discussed

Washington—Report that the Russians have developed an 8,700-mi. ballistic missile (AW Dec. 15, p. 25) has prompted speculation that the Soviets are attempting to outflank the coverage of the costly Ballistic Missile Early Warning System (BMEWS) the U.S. is now constructing in Alaska and Greenland (AW July 28, p. 19).

A spokesman for Radio Corp. of America, BMEWS prime contractor, says that the radar coverage will not be outflanked if the new ICBMS are launched from the USSR or its European satellites but could be outflanked if the missiles are fired from other parts of the world.

The 8,700-mi. figure quoted by Sen. Hubert H. Humphrey (D.-Minn.) following his interview with Soviet Premier Khrushchev (AW Dec. 15, p. 25) is not by itself significant unless corresponding payload size for this range is also specified since payload can be traded off for range.

Assuming that the new missile can carry a thermonuclear warhead over the 8,700-mi. distance, the ICBM would allow the Soviets to disperse missile bases southward into Turkestan and Southern Siberia, possibly even Tibet beyond the reach of current U.S. ballistic missiles.

This would be within the range of Strategic Air Command bombers operating from Middle Eastern air bases. But the Russians may believe that the U.S. will be forced to abandon these bases under Arab nationalist pressure.

However, moving Russian ICBM bases into southern portions of the country would bring them into closer range for Polaris-type missiles launched from U.S. submarines in the Arabian Sea and Bay of Bengal.

Some observers believe that the 8,700-mi. ICBM development was not originally intended to have this range but was begun at a time when thermonuclear warheads were considerably larger and heavier. When warhead size and weight reduction became feasible, development was continued to provide increased tactical flexibility and a more powerful launching vehicle for space probes.

The Russian ICBM could be used at shorter ranges with more powerful or multiple warheads. Or it might be lobbed in at low altitudes on a less efficient trajectory in order to take advantage of the earth's curvature to delay detection by BMEWS radars. (At a range of 3,000 mi., the earth's curvature prevents radar from seeing targets below an altitude of approximately 1,100 mi.) Low-altitude trajectory makes an ICBM nose cone a more difficult target to shoot down but also makes it less accurate.

Russia Calls for Push In Lightplane Field

Moscow—Russia is calling on its top designers to put the USSR ahead of the West and Czechoslovakia in building high-performance light planes.

At present, the Soviet press asserts, single-engine Russian aircraft such as the Yak-11, Yak-12, Yak-18 and An-2 are good enough for training, air taxi and feeder service, agricultural and other work, "but they can't set any world records. Other planes must be built for this purpose."

A. S. Yakovlev is said to be the only important Soviet designer to show much interest in high performance lightplanes. He has developed the Yak-18A and Yak-18P. The Russian Air Force newspaper Sovietskaya Aviatsiya wants designers A. N. Tupolev, S. V. Ilyushin, A. I. Mikoyan, and O. K. Antonov to lend a hand.

Most needed, Sovietskaya Aviatsiya says, are planes weighing between 1,100-6,600 lb. with a ceiling of 32,810-39,372 ft., a 3,105-3,726 mi. range and a speed of around 310 mph.

It also suggested that an amphibian patterned after the Soviet Shavrov Sh-2 be built for civilian and sports use.

President Approves Proposal For Federal Council for Science

By Ford Eastman

Washington—President Eisenhower last week approved recommendations for a new Federal Council for Science and Technology to promote closer cooperation among agencies participating in the nation's scientific programs and ordered that a directive be prepared to implement its creation.

Establishment of the council was recommended by the President's Science Advisory Committee headed by Dr. James R. Killian, Jr., chairman and special assistant to the President for science and technology, after a year-long study of the government's role in scientific research and development.

In his report to the President, Killian said the increased importance of science is imposing new requirements on the government to move forward on the broadest possible front. Research programs, he said, demand a more balanced division of effort among the various categories of research and development and greater stability and continuity.

Killian added that consideration must also be given to the capital requirements associated with expanded scientific activity in order to support and exploit new research opportunities and to improve, and sometimes invent, the tools of science themselves.

He said the government, by properly relating science to its policymaking activities, improving the management of its own research programs and devising means for supporting research in private institutions, can more effectively employ science and technology to solve today's specific problems. By doing this, he said, the government also can provide continued leadership on a wide scientific front in the years ahead.

The Science Advisory Committee said the special assistant to the President for science, a position held by Killian, should serve as chairman of the council.

Membership of the council would be composed of heads or top officials of any government department or agency with substantial responsibilities in science and technology. A suggested initial membership included the director of the National Science Foundation, commissioner of the Atomic Energy Commission, administrator of the National Aeronautics and Space Administration, Defense Department director of Research and Engineering, and representatives of the Departments of Health, Education and Welfare, Interior, Commerce and Agriculture.

Other departments and agencies with smaller research and development budgets should be represented when matters of concern to them are discussed, Killian said. He said a science advisor from the Budget Bureau and Secretary of State should attend as observers.

Functions of the council, Killian said, should be to:

• **Consider the impact of government** research and development policies and programs on non-governmental programs and institutions.

• **Consider problems and developments** in the fields of science and technology affecting more than one department or agency and recommend steps necessary to promote more effective planning and administration of the federal program.

• **Strengthen the government program** by promoting effective utilization of government resources and by promoting full cooperation among government agencies in program development.

• **Consider and recommend measures** for implementation of policy decisions affecting administration and conduct of the federal program.

Other recommendations made by Killian for the creation of a broad science and technology program included:

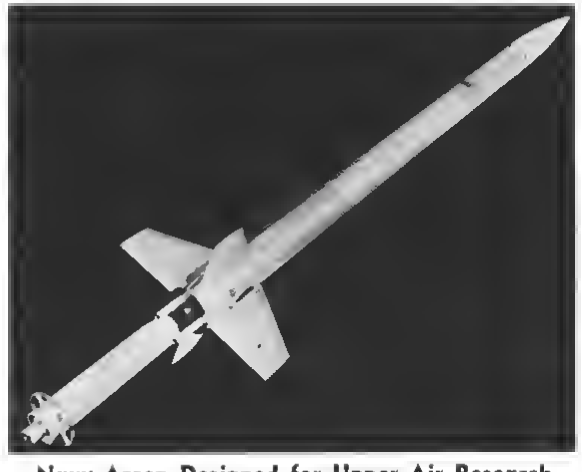
• **Strengthening government laboratories.** Each department or agency with scattered scientific and technical interests should designate a representative to provide unity and understanding at the policy level and to serve as representative to the new council.

• **Government-sponsored research** in non-government institutions. The committee estimated that funds spent by federal agencies in private institutions will rise from the present 59 to 66% by 1962. It added that the government has a serious responsibility not to divert these institutions from their own unique functions and missions which it termed vital to American life and culture. The committee called for a continuation of the project system of grants and contracts but said additional methods are needed in order to meet the full range of scientific opportunities.

• **Capital requirements for science.** Thoughtful and careful planning should be given the capital needs of science by both private and public sponsors of research. Lack of instruments and facilities is beginning to handicap the national scientific effort.

• **Private support of research.** Corporations and private foundations should be encouraged to contribute to the support of scientific research in academic institutions. Due to increased government support, there has been a hesitancy on the part of corporations and foundations to do so.

• **Support of research by state and municipal governments.**



Navy Arcon Designed for Upper Air Research

Navy Arcon high altitude sounding rocket is undergoing tests at National Aeronautics and Space Administration station at Wallop's Island, Va. New rocket, developed by Atlantic Research Corp., Alexandria, Va., will be used by Naval Research Laboratory to study upper atmosphere. Navy Bureau of Ordnance also will use Arcon for tests on vibration forces on solid propellant rockets. Arcon is designed to carry a 40 lb. payload to about 60 mi.

York Named Defense Director Of Research and Engineering

By Evert Clark

Washington—Dr Herbert F York, 37, last week left his post as chief scientist of Defense Department's Advanced Research Projects Agency to become the department's first Director of Research and Engineering. This office, created under the recent Defense Reorganization Act, will

- Absorb both the office of Assistant Secretary of Defense for Research and Engineering, last held by Dr Paul D Foote, and the office of Director of Guided Missiles, now held by William Holaday
- Supervise all research and engineering in the military services and in ARPA
- Direct some centralized research programs, although York said he does not intend to create "a vast centralized organization to take over what the services are doing." The services will continue to operate very much as they have in the past, he said.
- Serve as the chief scientific advisory group to Defense Secretary Neil McElroy

Both establishment of the office and the choice of York to fill it raise questions about the future of ARPA, created by the Administration chiefly as an answer to the criticisms of U S missile and space progress that followed the launching of Russia's first Sputnik.

Although the Administration placed considerable emphasis on the importance of a research coordinator in its reorganization arguments before the last Congress, it failed in its long search for a qualified scientist from private life to fill the job.

Fact that York was appointed only after the outside search failed is not considered by Pentagon observers to be a reflection on his ability. On the contrary, most observers feel that his departure removes the keystone from the ARPA structure.

York was ARPA's chief scientist, advising ARPA Director Roy Johnson and directing technical work. He also headed the Advanced Research Projects Division of the Institute for Defense Analysis. IDA is a private corporation of universities, created in 1956 chiefly to provide research talent on contract to the government at salaries higher than the civil service structure allows government to pay directly. IDA's advanced research division was ARPA's device for luring this sort of talent.

Pay Cut for York

York himself took a pay cut from his ARPA IDA salary, estimated at $37,000 to $40,000, to his new salary of $22,000 a year—equal to that of the service secretaries. He said his new office very well might make use of the IDA technique to acquire the talent it will need.

Asked about ARPA's future in a press conference held immediately after he took office, York recalled Deputy Defense Secretary Donald Quarles' recent statement that ARPA "is a permanent agency within the Defense Department, and will continue."

Asked repeatedly throughout the conference why ARPA needed to continue if his own office was to supervise and coordinate all defense research, York gave these answers:

- ARPA "will act in a way similar to the services' research and development" units.
- ARPA, "as in the case of the services, will continue to operate research and development problems under the general supervision of our office." But ARPA Director Johnson continues to report directly to Secretary McElroy.
- ARPA "will do specific programs which the Secretary of Defense assigns to it," while York's office will "supervise all research and development in the department."
- ARPA is an agency within the Department of Defense superstructure as distinct from the three services and "it or something identical would have to exist to carry out the programs that are to be" assigned to ARPA. York said it is "not just a name, but an agency and people who have familiarity with the programs they have been directing."

Asked if his office couldn't do the same job ARPA is now doing, York said "I suppose some similar arrangement could be made but at least for now ARPA remains. It is always possible that these things will be changed. They will be resolved as we go along."

- "At the present time, only ARPA (of all the defense agencies) can execute programs in space." This is done through the services.
- He expects no conflict with ARPA.

Office Staff

York expects his office to absorb the personnel formerly under Dr Foote—162 civilians and 60 military—and "the bulk" of the 30 civilians and eight military men formerly under Holaday. As for retaining Holaday himself, York said "I don't know. I hope to talk to him shortly." Holaday recently was named chairman of the Civilian Military Liaison Committee for the National Aeronautics and Space Council. ARPA employs 30 civilians, seven military men.

His office eventually will be "probably somewhat bigger than" Foote and Holaday's offices, York said. His chief deputy will be John C. Macauley, now deputy in the office Foote held.

Functions of the Guided Missiles Office will be taken over gradually enough to ensure no interruption of missile programs, York said.

First budget which York will supervise will be one which he had no part in making. It will include not only work to be done by the services, but that in ARPA and other Office of Secretary of Defense accounts and will include some authority to transfer funds between accounts.

York was asked when he expected to be "completely organized."

"I never expect to be completely organized," he said. "Continual change is the order of the day. We will change as we go. We don't ever expect to be static."

Herbert F. York

Washington—Before he became chief scientist of the Advanced Research Projects Agency last April, Dr Herbert F York, new Defense Department director of Research and Engineering, was director of the Livermore Laboratory, which the University of California's Radiation Laboratory operates for the Atomic Energy Commission. He was named a member of the President's Science Advisory Committee on Nov 30, 1957. At the time of his appointment to ARPA, York also was a member of the Army Scientific Advisory Panel and the Ballistic Missiles Advisory Committee. He is a former member of the Air Force Scientific Advisory Board. Dr. York is a physicist. He holds Bachelor of Arts and Master of Science degrees from the University of Rochester and a Doctorate of Philosophy from the University of California. He has served as assistant professor and associate professor of physics at California. Dr. York is married and has three children.

B-58 Orders

Washington—Air Force is purchasing 36 Convair B-58 supersonic bombers with Fiscal 1959 funds and reportedly plans to order another 40 during Fiscal 1960.

The Fiscal 1959 order, for which a letter contract has been let, brings the total of B-58s ordered thus far to 66. Air Force originally had planned to order more than 40 B-58s with Fiscal 1959 funds. However, design changes and rising costs cut the order to 36.

Drawing Visualizes USAF-Navy Bell D-188A VTOL Jet Fighter

Aviation Week artist's conception shows proposed Mach 2-plus VTOL fighter designed by Bell Aircraft Corp under limited Air Force-Navy sponsorship. Designated the D-188A, aircraft is scheduled to go into mockup this year. Powerplants are eight 2,000-lb thrust General Electric J85 turbojets—two on each wing tip, two in the center fuselage and two in the tail section. All eight can rotate from vertical to horizontal and vice versa for transition flight phases.

Contracting Changes Planned in Congress

By Katherine Johnsen

Washington – Defense Department contracting policy will be a major issue in the new Congress which opens this week.

The first attempt in 12 years will be made to rewrite and update military procurement law. Sen. Leverett Saltonstall (R., Mass.) will promptly introduce legislation giving legal recognition to contract by negotiation (see page 25).

Over 90% of the dollar volume of defense business is by negotiation. Yet, the 1947 Armed Services Procurement Act recognizes competitive advertised bid contracting as the standard. Negotiated contracts have to be justified by one of the 17 "exceptions" permitted.

Lined up in favor of the general objectives of the Saltonstall measure encouraging incentive type and weapon system type contracting are Sen. Lyndon Johnson (D., Tex.), Senate majority leader; the Department of Defense and the three military services; Aircraft Industries Assn., and numerous other industry representatives.

Strong opposition will come from small business. A substantial bloc of congressmen, skeptical of contract by negotiation, are expected to insist on attaching strings to the bill, including a strict set of rules on allowable costs (AW Oct. 27, p. 33).

These three issues will be considered separately from the Saltonstall measure:

• **Renegotiation.** Hearings on continuation of the law due to expire next Dec. 31 probably will start in February before the House Ways and Means Committee. Aircraft manufacturers are expected to be successful in obtaining one change in the law: right to appeal renegotiation decisions by the U. S. Tax Court to the U. S. Court of Appeals. Tax Court has upheld Renegotiation Board determinations of excessive profits in the majority of cases. Another major change Aircraft Industries Assn. will urge—that profits earned under incentive contracts be exempted from renegotiation—is more controversial.

• **Contractor Indemnification.** This legislation would authorize Department of Defense to indemnify contractors and subcontractors engaged in hazardous work up to $500 million for a single catastrophe, and will probably be enacted. The President is expected to request it.

• **Patent Rights.** American Patent Law Assn.—with strong backing from the Aircraft Industries Assn., will try to obtain patent rights for the inventor working under contracts from the National Aeronautics and Space Administration. The Patent rights now go to the government. The outcome of the issue will depend in large measure upon the membership of the Senate and House space committees. A new permanent committee will be named in the House, and the Senate committee composed last year of the chairmen and ranking minority members of other Senate committees, will be reorganized.

On Fiscal 1960 budgets for civil and military aviation, the pattern is expected to be the same as that of the past few years, the Democratic Congress will vote more funds than the Administration requests but less than that originally asked by the individual agencies. The Administration can utilize—or ignore as it has in the past—the added funds. Congress however, is expected to take a stronger role than ever before in deciding where defense funds are to go.

House Appropriations Subcommittee on the Armed Services has compiled a comprehensive staff study on missile and advanced weapons reliability on which to base its decisions. Rep. George Mahon (D.-Tex.), subcommittee chairman, has complained that Defense Department has spread missile funds too thinly over too many programs.

Commenting on "all this air clutter with missiles and manned airplanes and rockets," Mahon has complained that "decisions appear to rest to a large extent upon whether a particular missile can be made to operate, with insufficient attention being devoted to evaluating the need for a particular weapon as part of the overall defense plan."

Key senators say that these programs will be subjected to particularly close scrutiny. Army's Nike Hercules and USAF's Bomarc interceptor missile systems, short-range interceptors, aircraft carriers, and intermediate-range missiles. Congress is expected to welcome push for an acceleration of the shift in emphasis from intermediate to intercontinental missiles.

On the other hand, there is much criticism in Congress charging that the Administration has moved too slowly, largely for fiscal reasons, on these projects. Navy's Polaris fleet ballistic missile; Air Force's Minuteman multi-purpose ballistic missile; USAF's Hound Dog missile for the B-52G bomber; atomic powered aircraft, and the Pluto ramjet and Rover atomic powered rocket programs.

First order of civil aviation business will be legislation increasing federal airport aid from $63 million to $100 million a year (AW Sept. 15, p. 28). If necessary, Congress is expected to override a presidential veto.

Membership on the two committees with jurisdiction over civil aviation will be substantially changed.

• **Senate Commerce.** Four Republicans were defeated—John Bricker (Ohio), Charles Potter (Mich.), William Purtell (Conn.), Frederick Payne (Maine). They will be replaced by two Republicans and two Democrats. The committee composition will be 10 Democrats and five Republicans.

• **House Commerce.** The four top Republicans resigned or were defeated—Charles Wolverton (N. J.), Joseph O'Hara (Minn.), Robert Hale (Maine), John Heselton (Mass.). This advances Rep. John Bennett (Mich.) to ranking Republican member.

Here's the outlook on other civil aviation matters:

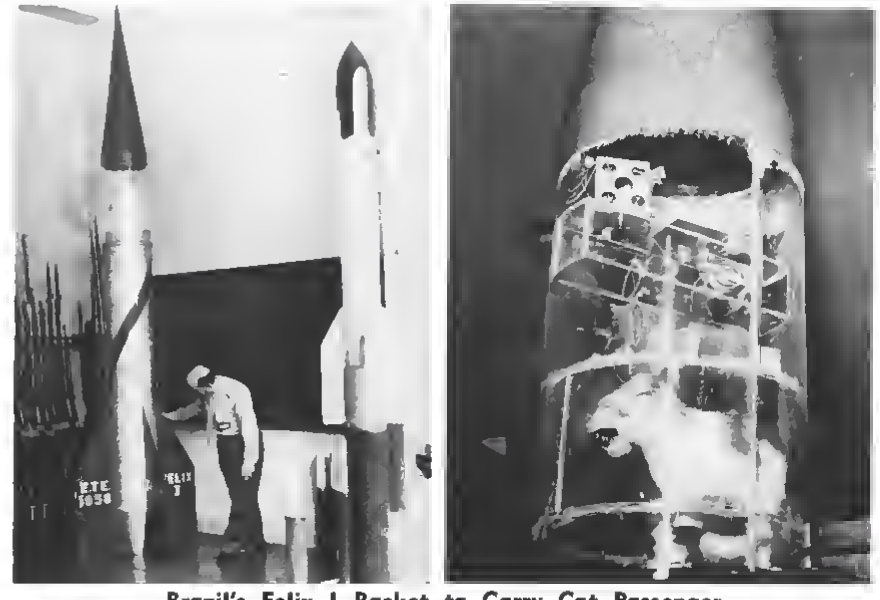
• **Transportation Investigation.** Senate Commerce Committee will move forward with a comprehensive study of the entire transportation field, with emphasis on a comparison of the policies of the federal government toward the different segments. Sen. George Smathers (D.-Fla.), a committee member, also has urged special investigations of the economic position of airlines and the need for new airline labor legislation—the airlines were placed under the Railway Labor Act in 1926.

• **Taxes.** Increase of the aviation gas tax—now two cents a gallon—probably will be injected into congressional consideration of the President's request for an increase in the general fuel tax from three to four-and-one half cents. Sen. Smathers will renew his drive for repeal of the 10% passenger transportation tax early in the session. He has the support of the majority of Senate Commerce committeemen.

• **Airmail Postage Rate.** This will be considered in connection with the President's request for an increase in the regular first-class mail rate from four to five cents an ounce.

• **CAB Ethics.** House Legislative Oversight Subcommittee headed by Rep. Oren Harris (D.-Ark.) will recommend legislation setting ethical standards and penalties for members of Civil Aeronautics Board—and other regulatory agencies—and industry representatives dealing with the Board.

• **Military Air Transport Service.** House and Senate Appropriations Committees—and probably others—will review MATS operations under a provision written into budget legislation last year requiring that $80 million be earmarked for purchase of commercial airline services. Airlines are dissatisfied, claiming MATS has considered this figure as a "ceiling" instead of a "floor."



Brazil's Felix I Racket to Carry Cat Passenger

Brazilian Army hopes to fire a cat into the ionosphere and bring it back alive sometime early this month, according to Col. Santos Lege, director of the Army Technical School at Rio de Janeiro. The rocket, "Felix I," a modified French Nord SS 10 anti-tank missile weighing 770 lb. (left), will be launched vertically to a planned altitude of approximately 112 mi. It probably will be fired from the Army's launching base at Marambaia, south of Rio de Janeiro. Maximum velocity is estimated at 4,470 mph. A uniform pressure cabin for the cat (right) will be equipped with a short-wave transmitter. Electrodes will be placed on the cat's head to measure its cerebral sensitivity during the trip. The cabin is scheduled to be recovered by means of parachutes. The parachute automatically opens by radio control.

AIA Endorses Saltonstall Bill

Washington—Representatives of Department of Defense, the three military services and the Aircraft Industries Assn. have endorsed the major provisions of comprehensive procurement legislation proposed by Sen. Leverett Saltonstall (R.-Mass.) (AW Aug. 18, p. 26).

Suggested changes were primarily to make the measure more workable and flexible to administer, less mandatory.

The legislation, introduced in the closing days of Congress last summer, provides:

• **Competitive negotiation would be encouraged** to the same extent that contract by formal advertised bid is now, with consideration being given to "quality" as well as price. AIA's representative suggested that "suitability" also should be considered.

• **Performance specifications** would replace the elaborate detailed specifications now required for even minor weapons. Defense and AIA representatives suggested that the matter be left discretionary to suit individual cases.

• **Fixed price or incentive type contracts** would be the rule—unless another type contract were specifically authorized by the agency head. AIA representative wanted the type further detailed since Defense now has a wide variety of fixed and incentive contracts.

• **Decentralization of military supervision** of research and development contracts would be encouraged and contractors would pay for "advisory engineering services" detailed to a specific project for the purpose of eliminating the numerous layers of review and approval now required. Both AIA and Defense representatives opposed reimbursement by the contractor.

• **Weapon system procurement concept** would be expanded to all major military "operational systems." Since "operational systems" is virtually impossible to define there was general agreement by Defense and AIA representatives and Saltonstall's staff that use of the concept should be discretionary. The net result would be a provision which would simply give weapon system procurement legal status.

AIA has proposed elimination of two highly controversial provisions included in last summer's version of Saltonstall's bill—renegotiation (see p. 24) and small business.

In the small business provision, Saltonstall's measure would require prime contractors to give "preferential" treatment "to increase the participation of small business concerns" in defense procurement. AIA, U. S. Chamber of Commerce and other industry organizations are vigorously opposed to this. It would require prime contractors to assume the obligations toward small business now assumed by Defense Department—such as reviewing each contract for subcontract "set-a sides" exclusively for small firms.

Failure to safeguard small business interests will mean strong opposition to the Saltonstall measure by the influential House and Senate Small Business committees.

Bureau of Aeronautics Schedules Avionics Division Reorganization

By Philip J. Klass

Washington—Major reorganization of Navy's Bureau of Aeronautics Avionics Division providing a structure that is subdivided according to types of warfare rather than by types of avionic equipment as in the past is expected to go into effect this month.

Reorganization, which has been under study for a year, is expected to aid in the coordination and integration of diverse avionic hardware that goes into modern Navy and aircraft missiles. It also reveals growing BuAer emphasis upon anti-submarine warfare.

The new structure will be the first major effort to provide an integrated organization for the variety of BuAer and Bureau of Ordnance branches that were merged two years ago to form the Avionics Division (AW Oct. 1, 1956, p. 27). Aircraft instruments and flight control subsequently were transferred into the Avionics Division from BuAer's Airborne Equipment Division.

New organization structure integrates the former weapon system project engineering group with the avionic equipment development groups (weapon system delivery, fire control support and weapon support systems). Three new "warfare groups" and one supporting group, and men expected to head them, are:

- **Anti-submarine warfare:** Capt. H. D. Helfrich, director.
- **Air defense:** Cmdr. L. M. Madden, director.
- **Combat air (attack aircraft):** Cmdr. R. J. Schneider, director.
- **Support systems:** Cmdr. F. L. Faulkner, director.

Director of each of the three warfare groups is responsible for development, application and integration of practically all of the avionic subsystems and equipment required for aircraft and/or missiles employed in his assigned area. Problems which formerly had to go to the director of the Avionics Division for resolution can now be resolved more quickly one level down, according to a BuAer spokesman.

Each of the three warfare groups contains a Systems Branch, consisting of project officers who act as "one-man WSPO's" to integrate all the avionic equipment used on a specific aircraft or missile. These men, usually Navy or Marine Corps officers, serve as the single point of contact on avionic matters for project officers in BuAer's Aircraft or Guided Missile Divisions.

Each of the three warfare groups also contains two other "component branches" responsible for development of specific avionic equipment and/or techniques required for their respective areas.

Some of these equipments and techniques—for example, communications, navigation and identification—have application to more than one type of warfare. The individual component branch is assigned to that particular warfare group where its equipment is most important and basic, but it also develops similar equipment for the two other warfare groups.

For example, navigation equipment is required aboard all types of aircraft, but the problem is most crucial to the mission of Navy's attack aircraft. For this reason, the Navigation & Control Branch is assigned to the Combat Air Group. Similarly, Communications & Identification Branch is assigned to the Air Defense Group because this is one of the most pressing problems for interceptor aircraft.

The Air Defense group also contains the Air-to-Air Control Branch responsible for intercept radars, computers, autopilots and air-to-air missile guidance and target seekers. The Electronic Countermeasures Branch is assigned to Combat Air Group.

The Anti-Submarine Warfare Group includes an Underwater Search, Detection and Classification Branch whose responsibilities include magnetic aerial detection equipment and air-dropped or air-dipped sonar gear. The weapons Branch of ASW Group includes specialists in nuclear warheads, anti-sub weapons, bomb racks and related hardware.

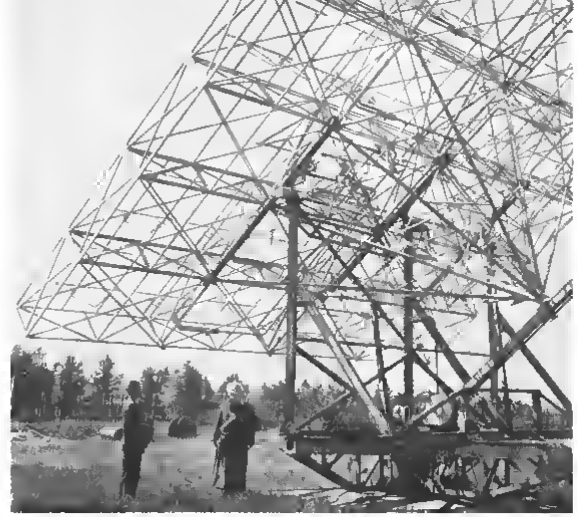
The Support Systems Group includes the Technical Analysis Branch, a new section being established to analyze mathematics and physics of new equipment and techniques proposed by contractors. Three other branches include Instruments, Technical Support (test equipment, specifications, value engineering, etc.) and Support (non-combat) Aircraft.

A BuAer spokesman emphasizes that avionic manufacturers, in most instances will be doing business with the same people as in the past, although they may be located in different rooms in line with new organization structure. For example, the old Fire Control Branch has been split into two sections. One, concerned with air-to-air (intercept) systems will be part of Air Defense Group, while the other, involved with air-to-surface (bombing) systems is assigned to Combat Air Group.

With the new organization structure, BuAer believes that Avionics Division can better handle its increased workload and be more flexible in shifting manpower as emphasis shifts from aircraft to missiles or vice versa.

X-15 Model Tested in Hypersonic Tunnel

High speed and altitude test is made on a 1/16 in. scale model of North American X-15 research aircraft for USAF Air Research and Development Command at Arnold Engineering Development Center's hypersonic tunnel. Technicians for Aro, Inc., which operates the tunnel, observes the model to check pressure probes attached near the canopy. Data on temperatures and aerodynamic loads are obtained.



SATELLITE TRACKING antenna above is one of a chain in USSR.

Soviets Detail Tracking Network

Washington—Earlier reluctance of Russian scientists to admit the existence of an electronic satellite tracking network has ended with the statement by the president of its Academy of Sciences, Alexander Nesmeyanov, that the ground stations are "equipped with radio technical and optical instruments."

First admission that electronic tracking is used came in an unsigned Pravda article, reported by AVIATION WEEK (AW Dec. 15, p. 48). The article simply mentioned the number of electronic observations made of three Sputniks without first stating that a network existed. Scientists at last summer's IGY meeting in Moscow refused to discuss this type of electronic tracking.

Nesmeyanov, writing in the magazine USSR, said stations in the tracking network "are continuously being refined and today comprise a complicated system of automatically functioning devices that gather, record and analyze highly accurate and predictive data."

Nesmeyanov said that Sputnik III:

- **Carried** several thousand transistors of various types. Programmer that controlled operations of the measuring instruments was "made up entirely of transistor elements."
- **Produced** audible radio signals at a distance of 6,000 mi. and more.
- **Maintained** temperature of its instrument compartment at between 60-70F.

Soviets Announce Space Plans

Washington—Soviet Union will launch a number of satellites before it attempts to put a man into orbit, according to Academy of Sciences' President Alexander Nesmeyanov.

Nesmeyanov's statement directly opposes widely printed speculation that Russia had not launched a satellite in the seven and a half months since Sputnik III or fired rockets toward the moon because its scientists were concentrating on a manned satellite as the next step in the Soviet space program.

While Nesmeyanov called a manned Sputnik "the next of the major projects of the space age" and said it is "very much on the working agenda of space engineers, space biologists and space medical researchers," he added that "a great deal of exploratory work will need to be done before the first man is launched into space."

Less dramatic but "more immediate," Nesmeyanov said are "the launching of wholly or partially recoverable satellites, the development of oriented satellites for many kinds of experiments which cannot be carried on under terrestrial conditions, and the design of 'eternal' satellites that will circle the earth at high altitudes and will have a practically unlimited life span."

News Digest

Third attempt to fire a full-scale Navy Lockheed Polaris fleet ballistic missile test vehicle from Cape Canaveral, Fla., failed last week when the missile deviated from course shortly after second stage separation and was destroyed by the range safety officer. Later USAF's twenty-fourth Thor firing ended in a destruct.

Official designation for USAF's Northrop T-38 jet trainer will be Talon, selected from about 5,000 entries in Air Training Command. First Lt. Larry C. Hewitt, Craig AFB, Ala., submitted the winning name. Twin-engined Talon T-38 now is in production at Northrop Division of Northrop Aircraft at Hawthorne, Calif.

Rohr Aircraft Corp. will seek additional funds for working capital and to retire short term bank loans through an offering of 300,000 shares of common stock directly to the public. This represents about $7 million at last week's market price. Based on current profits, the additional shares would drop Rohr's per share earnings last year of $4.28 about a dollar lower. Including this issue and allowing for full conversion of an outstanding debenture issue, Rohr's outstanding shares would rise from just below 1,000,000 now to slightly over 1,500,000.

Armstrong Siddeley Viper turbojet engine is under consideration by India's Defense Ministry for production in that country under license. Armstrong Siddeley negotiating team recently inspected Hindustan Aircraft Works at Bangalore to study manufacturing possibilities. Engine would be used to power Indian Air Force jet trainers.

Japanese Defense Agency will purchase 14 Allison J33 turbojet engines at $40,455 each for use in Japanese Air Force Lockheed T-33 jet trainers. The government also has ordered $300,000 worth of parts for Lockheed P2V-7 anti-submarine warfare plane overhaul and repair at Shin Meiwa Aircraft Co. plant. The T-33s are being manufactured by Kawasaki Aircraft Co.

First Britannia 253 turboprop transport designed as Royal Air Force troop carrier, has made its maiden flight from Short Brothers & Harland's Belfast, Northern Ireland, airfield. RAF has ordered 20 Britannia 253s which can be converted to either freighters or air ambulances. Aircraft can carry 115 troops is powered by Bristol Proteus 255 engines, producing 4,445 eshp. with water injection.

Economists Predict New Traffic Growth

Upswing in airline business after 15-month lull forecast on basis of general economy outlook.

By L. L. Doty

Washington—A decided upswing in airline business and a return to normal growth patterns after a 15-month traffic recession is now being forecast for 1959 by trunkline economists.

These optimistic views, in marked contrast to the general outlook throughout 1958, are based upon an anticipated improvement in the general economy in 1959 and a stimulation of passenger traffic through use of jet equipment.

Most economists are now predicting a steady, although unspectacular rise in general business activities that will make 1959 a record year and push the total output of goods and services well beyond the $470 billion mark by the end of year. Before 1959 ends, U.S. scheduled airlines will have a total of 78 turbojet and 210 turboprop transports in service.

Direct reaction of airline business to the general economy was confirmed last year when revenue passenger miles plummeted from a historic 13-18% annual increase to less than an estimated 2%. This critical decline in passenger traffic brought a halt to the industry's growth pattern in 1958 for the first time since 1945 (AW Dec. 8, p. 26).

Most airline specialists now feel that 1958's leveling-off condition will be reversed by an upturn in the general economy. They look to a 12% increase in passenger revenue miles for the domestic trunkline industry and a 10% rise in gross revenues.

A few airline officials are reluctant to give this rosy prediction a complete endorsement but they concede that the first six months of 1959 should see some improvement in the airline picture. Beyond that, they refuse to make any predictions for the year as a whole.

However, both the optimistic group and the conservative element are forecasting little or no improvement in the profit picture in 1959 for the domestic trunkline carriers. Expenses are expected to continue to climb throughout 1959 with labor costs leading the way. Cost of converting from piston-engine equipment to turbine-powered equipment also will dig deeply into profits.

The profit squeeze which first became evident in mid-1956, continued through 1958 when the 12 trunklines netted an estimated $30 million—second lowest profit recorded since 1949.

Exact amount of profit the industry will realize this year hinges to a large degree upon the outcome of the Civil Aeronautics Board's Passenger Fare Investigation which should be concluded late this spring. As of now—at the present fare level and in view of a forecasted 9% increase in expenses—profits for 1959 are estimated at $37 million as compared with an estimated $30 million in 1958 and actual net earnings of $27 million the previous year.

However, a rate boost could substantially revise this picture and put the airline industry back into a more attractive position as far as returns on investment are concerned.

Although the impact of jet transport service will not be felt fully until the latter part of 1959, most observers believe initial services by American and National airlines will have the effect of generating larger volume of passenger traffic than that normally experienced.

In this connection, Pan American World Airways reported an 18% gain in traffic during the last half of 1958 over the last six months of 1957. According to Pan American vice president Willis G. Lipscomb, the growth in transatlantic business was the result of improved business conditions and introduction of jet service. He added:

"The stimulating effect of the jets can be judged from the fact that advance bookings ... during the period January through April, 1959 are two-and-a-half times those on the books for a similar period a year ago."

Bright prospects for a traffic growth year are tempered somewhat by the current labor unrest which shows no sign of subsiding. During 1958, strikes grounded five airlines for a total of 207 days. A flurry of similar strikes, which threaten to continue into the first quarter of 1959, could feasibly cause the airlines to report a slow start in recouping their normal traffic growth.

Despite the sharp dip in the rate of traffic increase during 1958, the airlines made a better showing than did other intercity public transportation competitors. The gain of slightly less than 1% in passenger miles during the first half of year compares with a 17% drop reported by the railroads and a 4.5% decline registered by bus lines.

These facts have led a number of observers to conclude that the airline industry has not yet saturated its potential market and that the improved economic situation will accelerate the trend. During the year a number of carriers can be expected to follow recommendations of Dr. Paul Cherington (AW Aug. 11, p. 28) that major sales efforts should be directed toward the development of new traffic sources.

If successful, such campaigns could draw travelers away from the private automobile and lure "stay-at-homes" to air travel.

On the international scene, Sir William P. Hildred, director general of the International Air Transport Assn., forecasts that the number of passengers that will be carried by the international scheduled airlines during 1959 will approach the 95 million mark, compared with an estimated 89 million transported last year.

This predicted 8.5% increase represents a substantial improvement over the 4% increase reported in 1958 over the previous year—a decided drop from the 12% or more traffic increase performed each year during the last 10 years by the international carriers. Hildred attributed the 1958 decline to the economic depression but noted:

International air traffic as such showed unusual buoyancy during 1958 and proved to be less affected by last winter's unsettled economic and political conditions that we had expected. He added:

"There is now every indication that the tide of air traffic has recovered its momentum after the slow-down in the rate of increase during the last 12 months."

'Taxi Radar' Order

Washington—Airport surface detection equipments (ASDE) for 10 major terminals have been ordered from Airborne Instrument Laboratories by the Civil Aeronautics Administration.

New "taxi radar" will give control tower operators a continuous display of all surface traffic, including both aircraft and vehicles on runways and taxi strips. Initial deliveries are slated to begin in 18 months. The radars will be installed in the following cities: Boston, Chicago (O'Hare), Cleveland (Hopkins), Los Angeles, New York (Idlewild), Newark, San Francisco, Seattle-Tacoma, Washington National and Washington International (Chantilly). The 10 ASDEs will cost $1.8 million.

AW 650 Argosy Nears First Flight

Prototype Armstrong Whitworth Argosy turboprop freighter, shown at the company's Baginton, England, plant, is under preparation for its initial flight. Twin boom transport is the first in a family based on the packet fuselage principle (AW Dec. 8, p. 93), which includes the AW 660 pressurized military transport and the AW 670 Airbus, a short-haul type. Factory production schedule calls for 10 aircraft to be completed by late this year. Armstrong Whitworth also plans efforts to gain full U.S. and British certification by mid-1960. Aircraft is powered by four Rolls Royce Dart 7/2 engines developing 2,100 eshp. Maximum payload with full reserves is 27,000 lb. over 300 mi. stage.

Aeroflot Is Poised for 'Greatest Leap'

Moscow—Russian civil aviation is poised for the "greatest leap forward in the history of world transportation," according to Air Chief Marshal Pavel F. Zhigarev, head of the state-owned airline Aeroflot.

Between 1959 and 1965, the USSR expects to show an average annual increase of 31% in airline passengers carried and 29% in ton-miles flown. This will permit attainment of Premier Khrushchev's goal of expanding air travel "six-fold" during the seven-year period (AW Dec. 1, p. 63).

Marshal Zhigarev predicts that by 1964 the Soviet airline's annual traffic gain in ton-miles will be equal to total ton-miles flown in 1958. "Such a growth rate," he declared, "has never been known and never will be achieved by any type of transportation in any capitalist nation of the world, including the U.S."

Aeroflot's greatest expansion plans were made known at a time when U.S. airline business appeared to be leveling off. Revenue passenger miles flown by scheduled American carriers in 1958 rose only 1.8% over 1957, according to Air Transport Assn. estimates. U.S. airline economists, however, are now forecasting a new upswing in business during 1959 (see page 28).

Zhigarev said Aeroflot carried 59% more passengers during the first 10 months of 1958 than in the same 1957 period. Aeroflot releases no passenger mile or cargo ton mile totals and publicly deals only in percentages.

During the past two years, 50-passenger twin-jet Tu-104s and 70-passenger Tu-104As have accounted for much of Aeroflot's traffic gains.

Turboprop Goins

Beginning in 1959, turboprop transports will provide another major increase in capacity.

Aeroflot is counting on the Ilyushin Il-18 Moskva to become its turboprop workhorse. This 75-to-100 passenger plane has been in scheduled cargo service for several months.

Also slated for introduction during 1959 are the 84-passenger, four-turboprop Antonov An-10 Ukraina and the 100-passenger An-10A. The 130-passenger An-16 is under development.

Russia's huge, four-turboprop, double-decked Tupolev Tu-114 Rossiya transport—to be used in 120, 170 and 220 passenger versions—and the 100-passenger twin-jet Tu-104B will follow the Il-18 and An-10 into service.

In discussing Aeroflot's new transports, Zhigarev made no mention of the 100-passenger four-jet Tupolev Tu-110. This aircraft, first unveiled along with the Il-18 in July 1957, hasn't been discussed in the Soviet press for many months.

The Aeroflot head said the current Seven-Year Plan also will be marked by a tremendous growth of short-haul helicopter service in the USSR. Zhigarev disclosed that Russia's second inter-city helicopter line is scheduled to begin operation early this year between the Black Sea resorts of Sochi and Adler.

Aeroflot's first scheduled helicopter route was inaugurated last November.

between the Crimean cities of Simferopol and Yalta. Ten-place single-rotor Mil Mi-4s are being used.

Airport facilities, long neglected by the Russians, will receive unprecedented attention in the 1959-1965 period. As compared with 1952-1958, capital expenditures for airport construction and reconstruction will more than triple, according to Zhigarev.

Major projects include new terminal buildings at Kiev, Baku and Ashkhabad and reconstruction of Moscow's busy Vnukovo Airport. A total of 90 "trunk line airports will be built or rebuilt in the next seven years and the network of local fields will be "significantly expanded."

Modern Terminal for Kiev

The new Kiev terminal, scheduled, for completion in 1961, will be the first in Russia to incorporate modern, western style architecture. It will contrast sharply with Aeroflot's present unimaginative and overcrowded airport buildings.

Zhigarev said the Kiev terminal will provide maximum passenger comfort. Its 1,588,500 cu. ft. of area will be eight times that of the present structure. Features include a second floor observation deck and a long, roofed loading concourse.

Aeroflot also expects these developments between now and the end of 1965:

- "Three-fold" increase in the number of airports equipped for around-the-clock operations.
- Addition of "tens of thousands of kilometers" of new routes.
- Increase of "2.75 times" in labor productivity per ton-mile flown.
- A 30-35% decrease in over-all air transportation costs.
- Further reduction in passenger fares to a level approximating those of Soviet railroads.
- Rate of gain in airline passenger traffic "considerably exceeding the rate of passenger growth for Russian railroad, highway and water transportation."
- "Two-fold increase in aerial spraying, a 50% gain in aerial photo activity and a 2.2-fold" increase in plane miles flown for special-purpose aviation as a whole.

Federal Aviation Agency Adopts Final Structure, Absorbs CAA

Washington—The final organizational structure of the Federal Aviation Agency was adopted last week and personnel, functions and funds of the Civil Aeronautics Administration were absorbed by the new, all-powerful independent agency.

At the same time, rule-making functions of the Civil Aeronautics Board's Bureau of Safety also were transferred to the FAA. Although the agency was officially designated a member of the Air Coordinating Committee during the official integration of all civil governmental aviation groups, indications are strong that the ACC will soon be dropped as an active organization.

James C. Pyle, former CAA administrator, was named by President Eisenhower last week as deputy to FAA administrator Elwood Quesada as first predicted by AVIATION WEEK last Aug. 25 (p. 34). Pyle has headed the 20-year-old CAA for the past two-and-one-half years.

Under the approved organization pattern, the FAA administrator will be assisted by five executive officers and three assistant administrators. Operational functions of the agency will be handled by four major bureaus.

Alignment of executive offices:

- **Office of the General Counsel.** Daggett H. Howard, former deputy general counsel of USAF, has been named to this position.
- **Office of the Civil Surgeon.** This new office was created by Quesada to cover the increasing role medicine is playing in the field of aviation.
- **Office of Legislative Liaison.** John R. MacKenzie, former congressional liaison chief for the Department of Health, Education and Welfare, has been named to head the FAA office.
- **Office of International Coordination.** This office will handle all international activities and technical assistance programs throughout the world now being conducted by the CAA.

Administrative functions will be handled by three assistant administrative offices which constitute a special branch of the FAA and which report directly to the administrator. They are:

- **Assistant Administrator** of Management Services. Alan L. Dean, formerly of the Bureau of the Budget, has been named to head this department which will be responsible for general services, accounting, management analysis and programs and budgets.
- **Assistant Administrator for Plans** and Requirements. A new section in aviation agencies, this office will handle all forecasting of aviation needs. Functions will include aviation policy, economics, statistics, mobilization plans and radio frequency management.
- **Assistant Administrator of Personnel** and Training. This office will handle functions pertaining to personnel, recruiting, classification and wages, security, training and school operations. According to Quesada, the "specialized training demands of this agency will place greater demands than ever upon the Aeronautical Training Center at Oklahoma City."

Transfer of the main operating segments of the CAA to FAA have been planned to prevent any interruption of essential services or functions in air traffic control, safety, installation of facilities and rule making.

Airways Modernization Board was transferred to FAA by presidential order on Nov. 1 and was redesignated the Bureau of Research and Development, one of the four operating bureaus in the new FAA establishment. Technical Development Center of Indianapolis will be merged into the Research and Development Bureau as a functional part of the National Aviation Facilities Experimental Center at Atlantic City, N. J.

Major Bureaus

Here are the four major bureaus constituting the operational branch of the Federal Aviation Agency.

All bureaus report directly to the administrator.

- **Bureau of Research and Development** will handle all operations analysis, systems analysis and systems experimentation.
- **Bureau of Flight Standards,** which will be headed by former CAA deputy administrator William Davis, will be responsible for the development and enforcement of safety standards and regulations for aircraft and airmen. The department also will maintain certification and registration records.
- **Bureau of Facilities** will be responsible for the acquisition, installation and maintenance of all navigation and air traffic control equipment and for all matters dealing with airport and aid construction.
- **Bureau of Air Traffic Management,** David D. Thomas, former chief of CAA's office of air traffic control. The new FAA office will be charged with en route and terminal operations, communications, weather, airspace utilization and systems procedures.

Approximately $365 million appropriated for CAA operations and $102,000 from CAB funds have been transferred to the new agency. Personnel complement will initially total 28,000 and eventually be expanded to 40,000 people. Of this total, 135 will be military personnel.

Organization of FAA last week advances the establishment of the agency by one year from the original target date of January, 1960, set by the Eward Curtis group in its recommendations to the President for aviation facilities.

DC-7C Notes Covered

American Airlines sale of 25 DC-7Cs to General Aircraft and Leasing Co. at a cost of approximately $915,000 each is being covered by 11 non-interest bearing notes guaranteed by General Dynamics Corp.

First of the notes, which totals $22,875,000, matures on Feb. 1, and the final one is due in June, 1961. General Aircraft and Leasing Co., headed by Milton W. Arnold, former Air Transport Assn. vice president, will sell or lease the aircraft as they are delivered. The 25 planes will be turned over to General Aircraft and Leasing over a seven month period beginning Feb. 1.

Supplemental Request Turned Down by CAB

Washington—Civil Aeronautics Board last week emphasized its long-standing "hands off" policy in airline labor disputes when it denied applications filed by several supplemental carriers requesting expanded authority to aid in transporting excess traffic generated by strikebound airlines.

Ruling on applications filed as early as Nov. 24 by the Independent Airlines Assn. plus Universal, United States Overseas and Miami Airlines, the Board said "that it is in the public interest to leave undisturbed the play of normal economic forces in a labor dispute" except where the public might be without the necessary facilities.

In denying the requests, Board members dismissed portions concerning the Trans World Airlines strike since it has since been settled and said that the carriers failed to offer evidence that their services over the routes of strike-bound Eastern and American Airlines would be in the public interest since alternative scheduled air service is available.

"The Board has heretofore adopted," the CAB said, "and here reaffirms, a policy of denying applications for substitute air service where the asserted need therefore has resulted from a work stoppage, except where it is demonstrated that the public would otherwise be without transportation facilities."

Eastern fought the applications, reminding the board of its "hands off" policy and pointing out that any temporary lifting of the supplemental carriers' present 10-trip-per-month restriction might seriously injure Eastern's attempts to settle its strike. The trunkline added that sufficient substitute air service was available to minimize public inconvenience.

No-Shows Plague Non-Struck Lines

By Glenn Garrison

New York—Christmas holiday air traffic from this area felt the impact of American Airlines and Eastern Air Lines strikes, although most travelers who took a chance on getting airplane seats were accommodated by other carriers.

Suspension of service by the two big airlines cut traffic movements at New York metropolitan airports by perhaps 20% over all during the holiday period.

National Airlines ran about 12 extra sections a day during the holiday peak, accommodating almost all its standby passengers. On Dec. 24 passenger total from New York was about 3,000, almost double last year's figure.

National hired idled Eastern ticket counter and reservations personnel on a temporary basis to help out in the rush, adding about 80 persons to its normal complement.

Many standby passengers found seats because of a magnified no-show problem on Dec. 26, 434 persons failed to show for National flights from New York. Frantic travelers were making multiple bookings.

National's jet flights ran full during the holidays, accommodating some of the standbys. Airline has adjusted its Boeing 707-120 schedules to ease the tight utilization cycle (AW Dec. 22, p. 39). Daily Miami-bound flights now depart at 9:25 a.m. and 5:25 p.m. instead of 9:25 a.m. and 1:55 p.m. No jet flights have been canceled.

Trans World Airlines added 18 extra sections from New York during the period Dec. 19 through Dec. 24 and had scheduled more than 100 extra flights over its U. S. system from Dec. 19 through Jan. 6. Both TWA and United Air Lines said they were able to accommodate almost all passengers who wanted seats, though not necessarily on the flights they desired.

Northeast Airlines received a shot in the arm from the combination of holiday traffic volumes and shutdowns by the two major competitors over its routes. Northeast's system load factor was running over 90% during the holidays, with an average 1,600 passengers daily out of New York. Three extra daily New York-Boston sections were added for the period. Airline encouraged standbys to try for accommodation, was able to take care of most of them. The regular inducement: Northeast offers standby passengers a payment of their limousine fares to and from the airport if seats aren't found.

While the variety of factors such as weather and extra sections make it difficult to statistically appraise the effect of the strike on normal holiday traffic here, movements at New York International Airport provide one indication. Idlewild's tower controllers were handling about 600 movements a day prior to the strikes. This total has dropped to about 500 a day, with the exception of the Dec. 24 peak when the total was 625.

New York's Air Route Traffic Control Center estimates that the strikes cut the Instrument Flight Rules traffic which might have been expected in the region over the holidays by 15-20%.

At LaGuardia Airport, controllers estimate that American normally operates about 25% of air carrier flights and Eastern about 15%. Traffic movements at LaGuardia have been declining in volume over the past year and the strikes cut totals even further. Total LaGuardia movements in November, 1957 were 22,801, in November, 1958 with Eastern's strike beginning Nov. 24 the total was 19,744. The December, 1957, total was 22,349, up to Dec. 26, 1958, the total was 16,585.

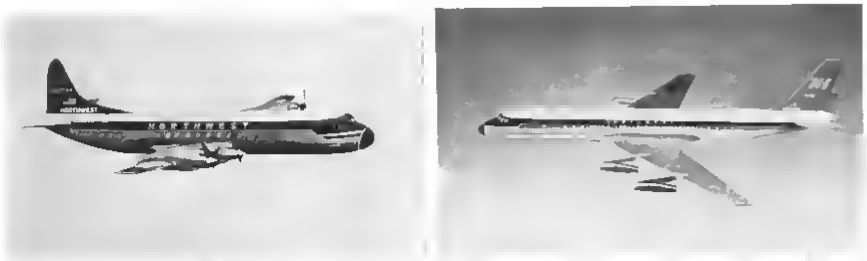
Break Possible in Eastern Strike

New York—Possible break in the Eastern Air Lines-Flight Engineers International Assn. dispute which has kept the carrier grounded since Nov. 24 appeared last week. The engineers said they would accept a Miami mediator's proposal with "minor" changes.

This move followed their rejection of a National Mediation Board proposal to the union and the airline that the strike be ended that negotiations be attempted for five days, and that the dispute then go into arbitration. Eastern had accepted the proposal.

In other labor developments in the industry, a strike threat against National Airlines by Air Lines Agent Assn. clerical employes was forestalled when the National Mediation Board offered its services and advised both parties that the status quo should be maintained until mediation processes were begun under the Railway Labor Act. Both parties replied that they would accept mediation.

American Airlines was still strikebound as Air Line Pilots Assn. delayed decision on a Mediation Board compromise proposal which the airline had accepted. ALPA had sought and received clarification from the board on several points in the proposal.



NORTHWEST AIRLINES' turbine planes on order, Lockheed Electra (left), Douglas DC-8 (right) are shown in carrier's markings

Northwest Adds Fuel on New Planes

Northwest Orient Airlines turbine equipment on order will carry increased fuel loads for long range operation, the airline said last week in formally announcing the orders. AVIATION WEEK reported Northwest's jet plans June 23 (p. 31)

The line's five Douglas DC-8s will include wing fillet tanks holding 1,380 gal. of fuel adding 9,108 lb. of fuel weight and 700 lb. of system weight. Northwest said the airplane's total fuel capacity, 23,307 gal. of kerosene, would make it a nonstop transpacific airplane westbound as well as eastbound.

An auxiliary center section tank (AW April 21, p. 102) also is provided in the overwater version of the DC-8 Northwest has ordered, and the total fuel difference between the Northwest airplane and the domestic version is 5,707 gal.

Maximum gross weight of the airplane is 310,000 lb. and Northwest plans to carry 118-176 passengers. It quotes flying time on its Seattle-Tokyo route at 10 hr. 15 min. westbound and 8 hr. 10 min. eastbound.

Northwest's 10 Lockheed Electras will be fitted with extra tanks in the wing to carry an additional 1,060 gal. of fuel. Northwest quotes range for the airplane as transcontinental but gives other specifications closely matching those previously laid down for the Electra. It gives its DC-8 normal range as 5,100 mi.

Runway takeoff length at maximum gross weight is given as 9,500 ft. for the DC-8 by Northwest, landing length at maximum landing weight is 7,100 ft. This compares with previous specifications for the overwater airplane of 8,400 ft. takeoff and 6,690 ft. landing (AW Mar. 3, p. 216A)

Full fuel loads on each airplane may require some compromise on payload, either cargo or passenger. The DC-8s are powered by Pratt & Whitney JT4A-3 turbojets (J75), the Electras by Allison 501-D13s.

Northwest has completed its financing program for the equipment (AW Dec. 1, p. 43). Donald Nyrop, Northwest president, said Northwest's delay in ordering jet equipment will work to its advantage in producing savings on interest payments on any down payment it would have had to make in ordering equipment earlier and also on progress payments as the airplanes neared delivery.

Unit prices Northwest will pay are $5,780,000 for the DC-8 and $2,400,000 for the Electra.

New Control System Planned by FAA

Washington—Federal Aviation Agency technicians are concentrating a major portion of their research and development funds on a new electronic data processing system scheduled to be the key to a fully semi-automatic air traffic control system by early 1963.

Initial installation of basic computers comprising the Data Processing Central System is being completed at the agency's new research and development center at Atlantic City, with actual experiments scheduled to begin on en route control problems by August and terminal control by March, 1960. First testing programs should take about one year to complete and will be conducted with a 50 target traffic simulator specifically designed for the New York area. In line with this program, FAA also will move most of its New York area Air Route Traffic Control Center to the Atlantic City site by mid-1959 and plans to channel live traffic into the new system in 1960 and 1961.

As applied to a routine flight, the data processing system goes into action before the aircraft leaves the ground. Instrument Flight Rule plans received by Air Route Traffic Control are fed into a computer and stored. Ten minutes prior to takeoff, the computer "activates" the plan through automatic punch and printers which prepare flight progress strips for the control tower, the IFR room and the center's departure and transition consoles. Personnel then mount these strips in a display on their consoles.

Tower operators, by means of a finger-tip keyboard, transmit estimated flight departures directly to control center computers which automatically search stored flight plans. If the tower operator's estimate does not conflict with any other flight plans, the computer signals back an automatic clearance to the flight data and local control consoles, where the local controller clears the aircraft for takeoff.

The local controller, after direct voice communication with the pilot and search radar monitoring, passes control of the aircraft to the tower radar departure controller, who then transfers the plane to an en route controller.

Position reports given by en route aircraft also are fed to the computer which automatically calculates and adjusts estimated arrival times for printing on succeeding flight strips.

Aircraft entering transition areas are first picked up by the radar sector controller at the ARTC and assigned a "tracking gate" which discloses identity of the aircraft. The tracking system then automatically gives the computer continuous information on the plane's position. The computer, in turn, calculates the time-to-touchdown for the aircraft, based upon all available data, plus the expected speed of the particular aircraft.

The sequence controller then assigns a landing time and order for the aircraft after checking the sequence for aircraft already assigned vacant times and aircraft unassigned.

Aircraft properly sequenced and arriving in the terminal area then come under the command of Air Route Traffic Control and a controller at an approach/departure control console. This controller then assigns his own "tracking gate" to the incoming plane and, aided by a computer in the control tower, furnishes vectoring information to the pilot so that the aircraft may enter the Instrument Landing System in the proper time and sequence.

SHORTLINES

► **Bahamas Airways,** formerly a wholly owned subsidiary of British Overseas Airways Corp., has been purchased by British businessmen David Brown and Eric Rylands. They have acquired 80% of the Bahamas shares with BOAC retaining 20%.

► **British Overseas Airways Corp.** has withdrawn its Boeing Stratocruiser aircraft from North Atlantic service. The BOAC Stratocruisers, which totaled 16 in the peak of their service, had made 12,700 crossings carrying 603,000 passengers since going into service on the route in December, 1949.

► **Capital Airlines** has named two new sales vice presidents as part of a program designed to place increasing stress on marketing activities. C. Ward Hobbs, formerly of American Airlines, has been elected vice president for customer service, a new department within the company's sales structure. Read Q. Chalfant, former assistant sales vice president, has been named vice president and sales manager. The airline's sales department is headed by Walter H. Johnson, Jr., senior vice president for marketing.

► **Civil Aeronautics Administration** received an apparent low bid of $12,493,475.46 for the paving of three runways and related work at the Washington International Airport at Chantilly, Va., (AW Nov. 24, p. 45) from C. J. Langenfelder & Son, of Baltimore, Md. The paving contract, when awarded, will be the largest issued to date for the construction of the new jet airport.

► **Flying Tiger Line** will offer all-expense tours and lower group charter fares during the 1959 summer season on its North Atlantic route. Groups using the new charter flight plan and the group custom tour may travel to Europe for as little as $560 per member including meals, hotels, tours and ground transportation.

► **First Fokker F-27 Friendship** for Norwegian use has been delivered to Braathens South American and Far East Airtransport (AW Dec. 29, p. 33). Braathens will use the F-27 on interior services which link Oslo with Norwegian west coast points. The new aircraft will replace the airline's Douglas DC-3s and de Havilland Herons.

► **United Air Lines** estimates a 1958 total of 7,200,000 passengers carried, up 8% from the previous year. Revenue airplane miles flown increased 4% to 135,215 million.

AIRLINE OBSERVER

► Move by 10 countries last week toward freer convertibility of their own money with the U. S. dollar and other currencies is not expected to have a strong effect upon airline traffic-business during the year. Most foreign exchange experts believe the move will improve the flow of trade between the countries involved and should result in some increase of business traffic on international routes. Such an increase, however, probably will be slight. Tourist traffic should not be affected substantially—particularly in such countries as Germany where the currency is already sound. However, some observers point out that the French devaluation of the franc will hike prices generally within the country, thus discouraging tourist traffic in France. In addition carriers selling traffic within France may suffer a slight monetary loss since fares probably will remain the same and, consequently, fewer dollars will be earned on tickets bought with the devalued franc.

► Pratt & Whitney has replaced last year's institutional advertising program with a sales promotional campaign designed to back airlines' efforts to sell jet transport seats. The manufacturer is distributing 30 quarter-scale models of its JT3C turbojet engine, which powers the Boeing 707-100 series, to its airline customers for display purposes. The working model is sufficiently exact to serve as a personnel training device. In addition, the company is providing airlines with animated cartoon movies and a four-color booklet, explaining jet principles, which is now being used by Pan American as a give-away on North Atlantic flights. P&W hopes the campaign will serve the dual purpose of accelerating popular acceptance of the jet while promoting its products within the airline industry.

► Civil Aeronautics Board General Passenger Fare Investigation is expected by most airline observers to continue on well beyond the original unofficial target date of early 1959." Best guess as to when a decision can be expected is now late spring.

► New York Airways new contract with its pilots provides a monthly increase of approximately $60 to first pilots flying 85 hr. per month. Contract became effective Jan. 1 and includes a retroactive lump sum payment back to June, 1958, when Vertol helicopters were introduced. No other substantial changes from the previous agreement were included in the new contract.

► Weather Bureau will begin weather forecasts early this year for jet flights operating on international and domestic routes between altitudes of 20,000 and 45,000 ft. Later this month, the Weather Bureau will distribute a new facsimile chart circuit showing high altitude wind flows over more than half the northern hemisphere.

► Coast and Geodetic Survey has published the first air chart covering the entire operation between Honolulu and the U. S. West Coast. Chart is oblique Mercator projection rather than the more common conic or regular Mercator projections. Chart is designed with an extension of polar grids and is suitable for plotting lines of position from celestial observations or electronic aids.

► Civil Aeronautics Administration has awarded a $5.7 million contract to the Admiral Corp. for the purchase of 39 basic semi-conversion systems to provide "daylight" displays of long range radar information for air traffic control. The equipment will be installed in air route traffic control centers during the year.

► Civil Aeronautics Board in a three-two decision denied a petition by Rutas Aereos Nacionales of Venezuela for permission to operate six flights per week between Port-au-Prince and Miami to transport produce on a charter basis during Nov. 6-Feb. 5 period. Board ruled that such an off-route operation would be regular air transportation and therefore denied. Dissenters were Board Members Joseph Minetti and Louis Hector.

► Capital Airlines is introducing a new "budget plan" that will allow passengers to purchase both domestic and international air travel on an initial down payment of only 10%.

Space Biology (Part III)

Zero Gravity Effects Largely Unknown

By Brig. Gen. Don Flickinger

A good many years before even the Russians thought seriously about either the feasibility or value of putting up an artificial earth satellite, Dr. Hermann Haber characterized the state of weightlessness as one of the great mysteries of space—"the true feel" of space.

Dr. Haber was working with Dr. Hubertus Strughold in the first laboratory group devoted entirely to consideration of space medical problems, at the Air Force School of Aviation Medicine commanded by Maj. Gen. Harry Armstrong.

Many of their original hypotheses on this condition made over 10 years ago have been borne out by the many investigations made since then by Henry, Ballinger, von Beckh and Ward. From the standpoint of the pure bioscientists, the phenomena of weightlessness existing in a space laboratory portends many exciting possibilities to test out theories of geotropism, communication biophysics, basic intracellular energy transformations and a host of other intriguing experiments which could not be done in any terrestrial laboratory.

However, for the space surgeon concerned as he should be for the in-flight efficiency and safe recovery of his space crew, the overall implication of weightlessness during the "coasting phase" of orbital flight considerably transcends pure academic interest.

Predictions Are Few

Our Air Force medical experiments studying the phenomena using parabolic flight paths with various types of aircraft are well known and need not be repeated here. Suffice to say we have been unable to study individuals or animals in this state for longer than 80-90 sec., and even with the X-15 research aircraft these time periods for study will not exceed five minutes.

It is therefore perhaps easy to understand why most of our scientists working in this field are reluctant to make extrapolations and predictions as to the total significance of this condition when it is imposed upon the individual for durations of from 1½ to 24 hr.

As in all good healthy scientific groups we have basically two different opinions on the effects of prolonged weightlessness. On the one hand that it will present no real psychophysiological difficulties to the space traveler and the other, of course, that it will seriously prejudice both his effectiveness and comfort and even his viability. However disregarding opinion I have attempted to review briefly some of the results of the work and thought applied to this most intriguing "space" problem.

I have further attempted to separate the discussion into first the physiological effects, and secondly, the indications for new types of equipment to be developed for use by the space pilot while in this condition.

The physiological parameters significantly affected by exposure to a zero G field include neurological mechanisms, spatial orientation, motion sickness, the cardiovascular system, the gastrointestinal system, body water elimination and skeletal muscle activity.

Concern has been voiced among medical investigators over the neurological mechanisms or potential effect of sudden withdrawal of the shower of sensory output from graviceptor transducers of the body. However there are many other sources of "neurological background noise" which may be ordinarily blocked out by the constant flood of 1G body positional information pouring into the central nervous system. This sensory output from the integumental surfaces and viscera may substitute for the normal gravity proprioceptive sensor outpourings subject training by artificial re-enforcement of skin pressure clues may offer an adequate solution.

Weightlessness

Whether and how usefully man can function in the weightless state is one of the greatest mysteries facing biomedical researchers. This and other biomedical aspects of space flight were discussed by Brig. Gen. Don Flickinger in a paper presented at a recent meeting of NATO's Advisory Group for Aeronautical Research and Development in Copenhagen, Denmark. Gen. Flickinger is assistant to the commander of Air Research and Development Command for bioastronautics, assistant deputy commander for research and surgeon to ARDC headquarters. Because of the thoroughness of his survey, Aviation Week has presented his paper in three parts. This is the last.

Deepness and restfulness of sleep under these conditions is presently open to question; drugs may be required to give restful, fatigue-relieving sleep. In addition, violent nightmares may disturb the rest of the suspended, sleeping astronaut.

Spatial disorientation as a response to the weightless state has been reported several times under both operational and experimental situations in parabolic maneuvers. In virtually all such cases it appears that these incidents resulted from attempts to "free float."

Such difficulties are generally obviated when the individual is comfortably restrained, with extremities resting against solid objects. However, unrestrained locomotion about a space cabin may cause some degree of disorientation. Cabin design and coloring to indicate "floor" and "ceiling" will assist in maintaining spatial orientation by visual means.

Motion Sickness

Individual susceptibility to nausea and vomiting or so-called motion sickness under the relatively simple and experimentally reproducible conditions of ordinary aircraft flight is poorly understood. Any attempt to derive definitive conclusions from the complex motion situation prevailing in the production of parabolic trajectories by jet aircraft is therefore fallacious.

Cognizance, however, must be made of the reports by Graybiel, et al., of illness in approximately one third of subjects exposed to such flight conditions. Most although perhaps not all of these responses may be explained by the nature of changing acceleration fields upon entry and exit from thrust maneuvers, the flying experience of the subjects, the "weightless regurgitation phenomenon," etc. The extent to which the weightless state alone influences this sickness incidence will probably remain in doubt until initial manned orbital flights are completed.

It is generally felt that no serious effects on the heart and blood vessels will result from life at zero G, at least during the short duration of the early orbital flights. One interesting fact reported from the Sputnik II experiment was the unusual lag in return to normal rate of the pulse of the canine passenger from the tachycardia induced by rocket boost.

Some degree of over-filling of the

right heart, shifts of venous pooled blood and minor changes in electrical and anatomic cardiac axes may occur but there is no reason to believe that cardiovascular instability and/or insufficiency will result. There is certainly more basis for predicting cardiovascular symptomatology in subjects thoroughly "acclimatized" to zero G when they return to a normal accelerative environment on earth.

Gastrointestinal Problems

Prior to the space age we had never been required to study gastrointestinal functions without the benefit of either its own weight or the weight of the food within its lumen. Obviously the primary physiological problem of handling any sort of foodstuff is to successfully accomplish swallowing.

Experimental observations of the deglutition mechanism under weightless conditions have indicated that with normal mastication of solids, swallowing of the semi-liquid bolus of food offers no difficulty. However, bolting of solid foods by the space pilot may have far more serious consequences than under terrestrial conditions. Poorly chewed solids tend to be swallowed with difficulty, indeed these particles may occasionally float over the palate; therefore the danger of aspiration is real.

The competency of the cardiac sphincter of the stomach under these conditions is dubious. During parabolic jet maneuvers a "weightless regurgitation phenomenon" mentioned earlier has been demonstrated.

This consists of the regurgitation of part of the stomach contents when a blow or even pressure is imparted to the abdomen. However, this is most often observed after and associated with ingestion of large volumes of fluids. This serves to point out the need for fairly rigid dietary control particularly with respect to fluid volume per feeding.

Many years ago Hoelzel completed a comprehensive study of the passage of inert materials through the intestinal tract in which materials with widely varying densities were surveyed. It was learned that the rate of passage of these materials was largely an inverse function of density. Therefore under a zero G field, food passage time may be slightly reduced. Considering the G length of the intestine and the surface tension of the semi-liquid intestinal bolus, the absorption of metabolites appears to offer no problem.

Elimination of body waste solids and liquids is a function of elasticity of vesicular and visceral tissues, voluntary musculature function, sphincter action and only to a very slight extent gravitation. In one study, micturition function was demonstrated in the weightless state with 26 subjects. Fifty-eight of these individuals noted a diminution or total absence of the sense of urgency upon attaining the zero G state with distended bladders, yet with training, voluntary urination was accomplished.

Studies by Gemelli and others of psychomotor performance, particularly eye-hand coordination tasks, indicate that compensation for the loss of upper extremity weight is rapidly learned. Manipulation of the cockpit controls and environmental components by the space pilot is therefore not anticipated to be a difficult problem. Learning new locomotion techniques will undoubtedly be more difficult because of the relatively greater mass of the lower extremities.

Abortive attempts have been made to study function of single cells while weightless. The lack of weight differentials of cellular constituents may in some measure affect cell metabolism. I might say parenthetically that an attempt to maintain a tissue culture under focus and make photomicrographic movies while unrestrained and weightless in the rear cockpit of a Starfire jet aircraft presents some amusing as well as perplexing problems.

We can already foresee the need for a series of new devices or improvements in currently operational equipment for pilot use in weightless situations. Preliminary work along these lines has already begun to a limited extent at military and civilian research centers. New and original ideas must be incorporated in the design solutions of weightless conditioning simulators and trainers, recreation and sleeping facilities, human waste disposal devices and food dispensers.

Considerable development of ground based operant trainers will be required. These may be based on the principles of either air-bearing or magnetically suspended platforms for development of space pilot proficiency in the manual use of small reaction jets—or radically different designs may be required. Other trainers may be required to increase agility in zero gravity locomotion e.g. utilizing magnetic shoes in an underwater tank, teaching of subjective relaxation and sleep with lack of support may become a part of the space pilot's "pre-flight" training.

POINT of separation of booster package from Atlas 10 B satellite vehicle is shown by Maj Gen Bernard A. Schriever, chief of USAF Ballistic Missiles Division. Standard propulsion, fuels and guidance systems were used (AW Dec. 29, p. 18).

Other Devices

Other devices will be required which will assist the space crew in gradually learning to accommodate to their new environment e.g. graded inertial restraints on extremities, capable of giving sensation of 1G etc. until complete zero G familiarization has been achieved.

We will require the development of a lightweight collapsible restraining bed with sufficient differential pressure cuffs on anterior and posterior body integumental surfaces to give real psychological 'top-bottom' information to the individual even while asleep. Although some degree of restraint is required the device must permit comfortable and relaxed sleep.

Sanitary, lightweight, and esthetically acceptable human waste receptacles must be developed. Their design must incorporate the principles of gravity-

independence and positive action flow, e.g., a venturi.

Virtually an open field exists in the requirement for design of devices to assist in free-fall locomotion for movement inside and outside of the space vehicle. Lightly magnetized shoes and gloves, non-protruding hand holds, and small hand-held reaction guns for extravehicular use are but a few of the fascinating challenges facing the bioastronautical design engineer in the area of human weightless locomotion.

Of course, all bioanalytic systems within a space craft must be designed for zero G function. However, one of the most critical requirements as has been previously mentioned herein will be the need for a liquid oxygen converter. This device must prevent excessive liquid oxygen boil-off, maintain the liquid-gas interface and function as reliably under high G loading as in the weightless state. A similar requirement for bio-engineered hardware development may arise for the liquid suspensions of photosynthetic gas exchanges, should these systems prove feasible for flights of long duration.

Food Equipment

Finally, serious human engineering consideration must be given to the design of equipment for the storage, heating and dispensing of both liquid and solid foods. This container-dispenser must be capable of storing large quantities of materials for prolonged periods. They must provide safeguards against bacterial or fungal contamination, spoilage and accidental spillage. Provisions must be made for placing the dispenser directly into the mouth for introduction of the liquid or solid.

The first experimental study of this problem was conducted at the Air Force School of Aviation Medicine, beginning in 1956 and although some difficulty was anticipated in the handling of foodstuffs under zero gravity, one were not entirely prepared for all of the difficulties imposed by the mechanical problems of drinking fluids from open containers.

I have attempted to review the more pertinent biomedical factors involved in manned orbital flight at altitudes and for durations consistent with booster energies currently available or realizable in the near future.

No attempt has been made to establish a time-table for significant events in manned space operations since I have neither the technical knowledge nor program information which even a reasonable authentication of such prediction would require.

Nor has an attempt been made to prophesy or make a case for man's eventual full scope of usefulness as an operating component in future space vehicle systems whether the basic mission be peaceful exploration or military patrol. From a personal standpoint, there are far too many unknowns in manned space operations to hazard, at this time, an thoughtful or useful predictions. At the same time, I cannot resist the opportunity to expound one small bit of personal belief and philosophy.

Man's personal exploration and exploitation of space is inevitable and the costs both in lives and dollars will largely be reckoned by the logic and soundness of his approach to this great challenge. At best a tremendous amount of scientific, technical, and economic resources will be required to achieve even the most modest objectives. On the other side of the ledger, there are equally tremendous potential benefits to mankind—health, happiness, productivity—to be realized from the successful accomplishment of this ambitious objective. I would not think that outer space will be found to contain any new and mysterious ingredients capable of ameliorating man's terrestrial miseries and conflicts, but instead that the nations of the world in joining together to achieve a successful solution of the many attendant problems, will learn as a by-product how to work and live together with common understanding, trust, and tolerance.

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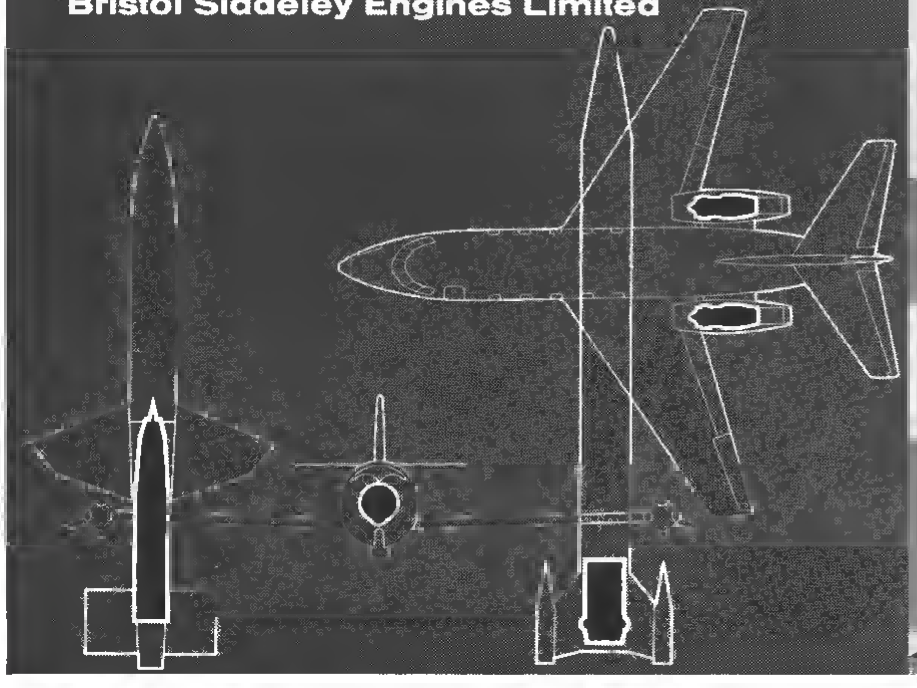

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BRAIN POWER translated into FLIGHT POWER

Thiokol Stresses R&D on Rocket Motors

By Craig Lewis

Marshall, Tex.—Experience of Thiokol Chemical Corp. at its rocket plant here shows that manufacturing solid propellant rocket motors is a production job that involves a heavy dose of research and development.

Working for stable, volume production of solid rocket powerplants, Thiokol's Longhorn Division not only has to contend with constantly advancing solid rocket technology, but is in a continuing search for new, more efficient means of producing the motors.

Thiokol is operating Longhorn Ordnance Works here for the Army, and the facility has been developed as a production plant for small and medium-sized solid motors. Currently, Thiokol is producing the composite propellant Falcon, Lacrosse and Nike Hercules motors and spinner motors for Honest John, and production is starting on the Sergeant motor.

During the years the company has operated the Longhorn facility, there has been a shift in military philosophy from the use of free flight ballistic rockets to the use of guided missiles. Moving with this shift, Thiokol has had to adapt its operation from production of such small rockets as 2.75 in. air-to-air types to building powerplants like the Lacrosse motor with its 500 lb. of propellant and the Nike Hercules sustainer containing more than a ton of propellant.

While the switch from small to large motors is the sharpest change the Longhorn Division will probably have to face, Thiokol knows that larger motors than those now in production are coming. This advance in size as the solid state of the art advances is a constant consideration in the planning of facilities and development of production techniques. I. F. Nauman, general manager of Longhorn Division, told AVIATION WEEK that Thiokol is trying to look far enough ahead to build facilities which can handle the larger motors when they are released for production.

Expansion Program

Longhorn is a World War II TNT plant, part of which has been converted by Thiokol and the Army into a manufacturing plant for solid rocket engines. Thiokol now has 1,300 employees at work in the 8,800 acre ordnance works, which is in the midst of a $6 million expansion program.

Nauman points out that there are a number of ways flexibility can be designed into a facility, including building bigger work bays than might be needed right now so they can be easily adjusted to larger motors in the future. One limiting factor is the fact that safety calls for heavy concrete walls in many areas, and this means that, unlike many production facilities, changes can't be made merely by shifting partitions and tearing down light walls.

In building new facilities, common sense dictates that they be constructed as cheaply as possible so they won't be too expensive to modify or tear down to accommodate future developments in solid rocket work.

Observing that solid rocket manufacturing has to be a lot closer to research and development than other types of production, Nauman said that by the time a motor and its production process is really refined, it is often obsolete. He said Longhorn has a dual function of quantity production and a kind of research and development work best described as product engineering.

Longhorn Division takes on the production job after a solid motor has been developed as a research project elsewhere. The job then becomes one of finding an industrial method for volume production of the new motor with safety and economy, according to Longhorn's technical director H. Q. Holles.

Research and development aspect of the job is apparent in the continual search for more efficient production methods which goes on at the same time that Longhorn is manufacturing solid motors with current methods. In this effort to improve production techniques, an Army contractor plan called Master Industrial Engineering Program is cited by Holles as a very valuable tool.

Under MIEP the contractor proposes research projects which might lead to better production methods. If the Army approves a project is funded and carried out by Thiokol under a specific contract. Army holds annual review conferences with the contractor and others who might contribute to the state of the art. Projects are reviewed in light of changing requirements and new studies are considered. Originally these projects were aimed at developing an automated production line for small rocket motors like the small air-to-air rocket, but now the emphasis is on the larger motors.

A survey of the production method Thiokol now uses to turn out Falcon, Lacrosse, Nike Hercules sustainers and Honest John spinner motors shows some of the improvements developed under MIEP. It also shows where some innovations now in the works will mean further changes in production technique.

Production Cycle

Motors start through the production cycle in a receiving area where the steel cases and their fixtures are inspected, weighed and measured to make sure they meet specifications. When the engine case is ready to be processed it is cleaned in a vapor degreasing system, then the interior is sprayed with steel grit to clean out any rust or foreign material and to roughen its surface.

The engine case goes through the manufacturing process in a steel harness which protects it and makes it easy to handle. Case and harness are carefully weighed at the beginning so the exact weight of the propellant can be determined when the job is finished.

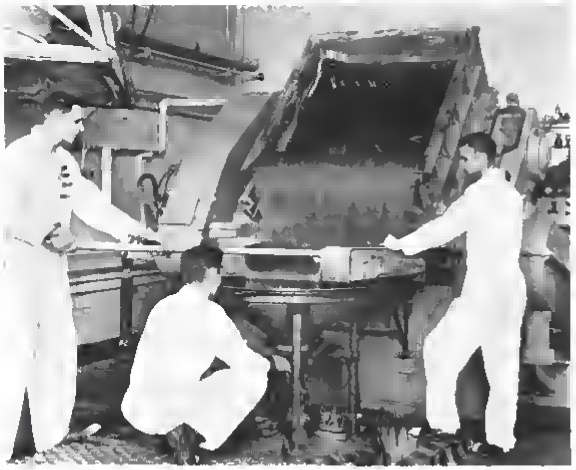
In the next step the case gets a liner which serves as both insulator and binder between propellant and case. This is a Thiokol liquid polymer mixed with a carbon black filler and curing agents which forms a liner about ¼ in. thick.

A new technique has been developed under MIEP for lining such engines as Lacrosse. Under the old method which is still used for the larger engines, lining material was poured in the case, the case was rotated and the waste was pumped out. With the new system, a sprayer is traversed through the case while it is being rotated. New method cuts waste and gives the case a more uniform lining.

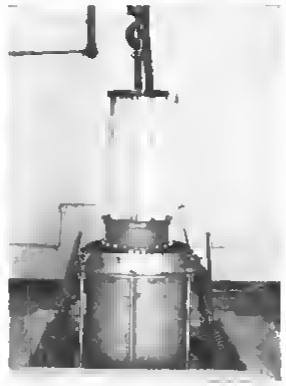
After they are lined, the engines move slowly through a curing oven on an overhead conveyor for a set time at a controlled temperature.

The blast tube for the Nike sustainer presents a different lining problem since it carries the exhaust gases from the motor back through an area containing control system components. To protect these components skin temperature of the blast tube must stay below 300 deg. The tube is lined with a Hycar liner which is an asbestos filled phenolic plastic material ½ to ¾ in. thick. The molded liner is painted with the Thiokol liner material inserted in the tube and then cured.

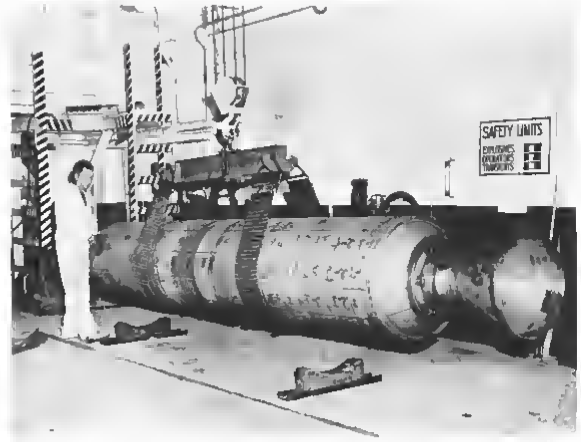
While the case is going through this cycle, the propellant is going through a critical process of preparation and mixing. Oxidizer is prepared by drying and grinding for a specified particle size according to the motor's burning characteristics. It goes through a hammer mill, screen and blower, then is con-



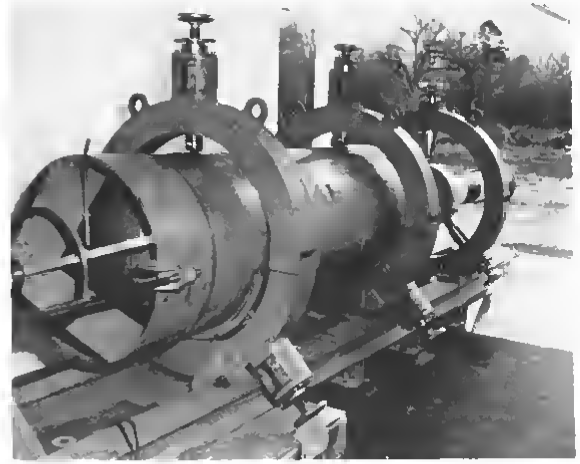
COMPOSITE solid propellant is mixed in 200 gal. sigma blade Baker-Perkins mixers. Oxidizer is incorporated in fuel binder system while fuel binder is in liquid state.



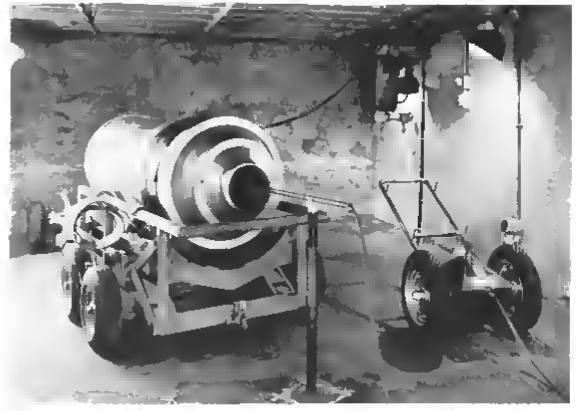
FALCON missile rocket motor gets radiographic inspection by 250 kv. X-ray machine. Exposures are made in both vertical and horizontal positions. Interpretation of finished radiographic film yields information to determine grain integrity and cavity alignment.



SOLID propellant powerplant, sole source of power for Sergeant surface-to-surface missile, is shown in one step of manufacturing operation at Longhorn Ordnance Works.



XM-30 sustainer motor for Nike Hercules missile is restrained for static testing. Motor is free to move in a direction coincident with the line of thrust.



ROCKET motor is inspected internally by use of Co^{60} sources of various radiation levels. Radiographic film is positioned on motor shell, Co^{60} source is inserted by remote control

veyed to hoppers for transport to the mixing area.

The fuel is a polysulfide polymer. It is pre-mixed in batches before it is blended with the oxidizer. The polymer is weighed, then it is pumped into a tank where certain additives are dumped into it. These dry components are blended with the liquid polymer, and the fuel is then run through a colloid mill where shearing forces give complete suspension and dispersal of the additives in the polymer.

In another batch sulphur is mixed with polymer to accelerate the curing process and certain metal powders which will be added to the propellant are mixed in a slurry. The various propellants contain from six to eight different ingredients.

At this point, the ingredients are mixed into a propellant. After weighing, the oxidizer runs down through a screen into a 200 gal. sigma blade Baker-Perkins mixer. The fuel is added, and the mixing starts. Mixing lasts from 35 to 90 min., and the metallic slurry and sulphur mixture are added about 20 min. from the end of mixing time.

Curing Cycle

The mixing process blends the materials and reduces viscosity. When it is completed, the propellant is dumped through a slit plate to remove air trapped in the mixing cycle. Propellant reaches a temperature of 140 deg. during the mixing operation and it starts through the curing cycle at that temperature.

An MIEP project has improved the production process at this point. A study of the mixing operation was made and changes which resulted have cut mixing time in half. A complete change in mixing technique will probably emerge from yet another MIEP project.

This project, which now is in the development stage, would substitute a continuous mixer for the batch mixing method now in use. New mixer will take materials from the pre-mixing stage and combine them in a continuous operation. A screw extruder will de-aerate the mixed propellant and act as a pump to load the propellant into the engine cases.

Rather than mixing a batch at a time, Thiokol will have a continuous

AFTER propellant has been cured and has taken solid shape, cavity forming fixture is removed by remote control from a center located in a processing building.

source of propellant for its casting operation. One propellant mix can be run through the mixer for a production run of one type of engine, then the system can be switched to another mix for a different engine. With the continuous mixer less propellant is actually in the mixing machinery at one time.

Metering System

Key element in the continuous mixing operation is a new loss-in-weight metering system Thiokol will use for feeding the continuous mixer. Materials in the pre-mixing phase will continue to be mixed in batches since it is almost impossible to control ion percentages of dry materials in an automatic system.

Company says the continuous mixer will be safer than present batch mixing methods especially in view of high energy fuels coming along. The system can be isolated in a concrete facility, controlled remotely and monitored by television. It is similar in principle to the equipment used in the on-site loading scheme proposed by Thiokol for loading very large solid motors (AW Jan. 28, p. 43).

Continuous mixer is expected to be in operation on a pilot line basis early in 1959 to see whether it can match the accuracy of batch mixing. Hulley predicts that it will improve on batch mix accuracy. New system involves specially designed mixing equipment, but most components are off-the-shelf items.

Ability to predict performance is a critical element in production of solid rocket grains and Thiokol tests samples of ingredients and propellant at various points along the line to make sure they meet specifications.

New Test Methods

Longhorn Division is working on a number of new test methods under MIEP. For current propellant types, the company has developed new chemical and ballistic means for testing the mixed uncured propellant in a system of in-process quality control. New tests techniques are under study for future propellant types. Right now, wet chemical analysis is the choice for chemical testing, and a closed bomb method probably will be used for ballistic testing of the uncured propellant. In the closed bomb test, propellant is burned in a closed sphere, giving a measurement of burning time and pressure.

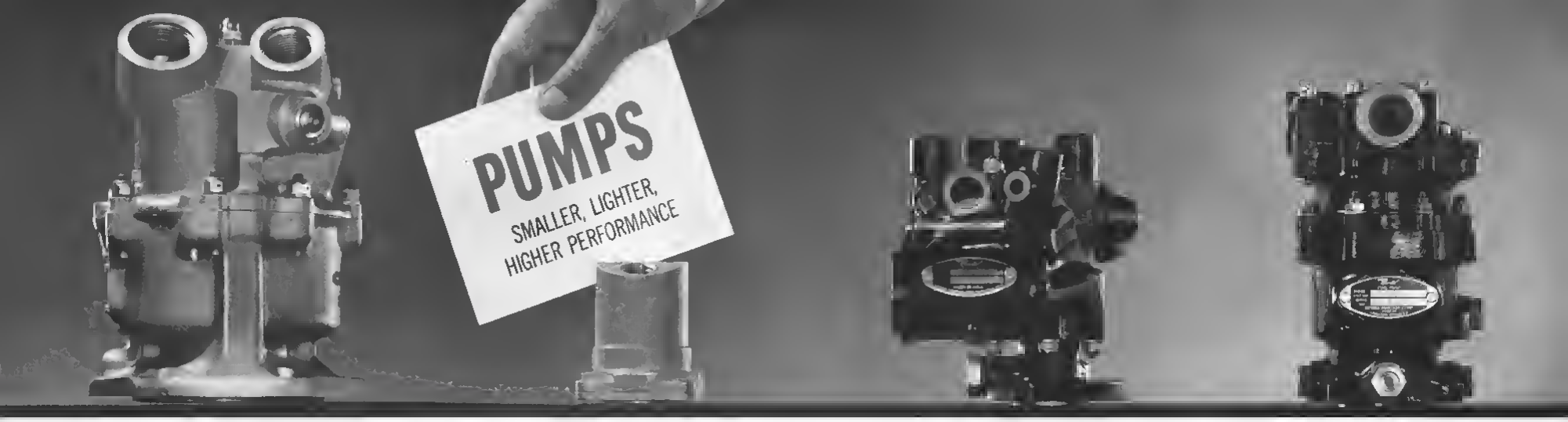
The other possibilities for ballistic test are vented vessel and strand burning systems. Vented vessel is a vertical rocket motor which is filled with propellant and which end-burns, providing measurement of pressure and time. In strand burning a tube is forced full of propellant and time is measured when the propellant burns down through two timing wires.

A chemical analysis method which has future possibilities involves nuclear magnetic resonance and electron paramagnetic resonance. Southwest Research Institute has worked on this project for Thiokol. Right now it is a research tool, but it may develop into a quantitative control test which will give a rapid reading on constituents. Both nuclear and electron resonance systems have been dropped for polysulfide systems but they may be used for rockets now in the research stage.

Thiokol hopes that some combination of such methods as wet chemical analysis, X-ray inspection, nuclear and electron resonance and closed bomb will furnish an instrumented method of testing propellants in the production process for the fidelity to specifications which is necessary in predicting rocket performance.

Once the propellant is mixed, it is ready to be cast and cured. The engine case is set in an upright position, with the rear of the engine at top and a mandrel is seated in an alignment sleeve in the bottom or front, of the case. This mandrel is shaped to form the internal geometry of the grain.

The mandrel is raised to allow the propellant to flow into the case through an opening in the bottom. Case is loaded from the bottom to avoid trapping air in the propellant. When the



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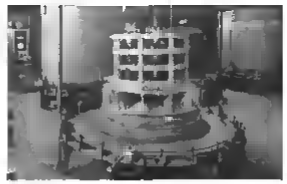

complex assemblies such as turbine burner rings, manifolds, etc., up to 42" in diameter.

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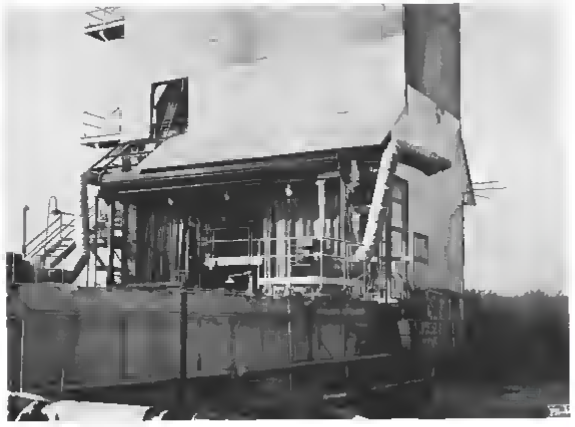


Thor, Jupiter Test Stand Enclosed

Thor and Jupiter liquid propellant rocket engine test stands at Neosho, Mo., plant of North American's Rocketdyne Division are enclosed and heated for winter tests. Large steel door is being installed under the overhang to keep stand closed except during actual firing.

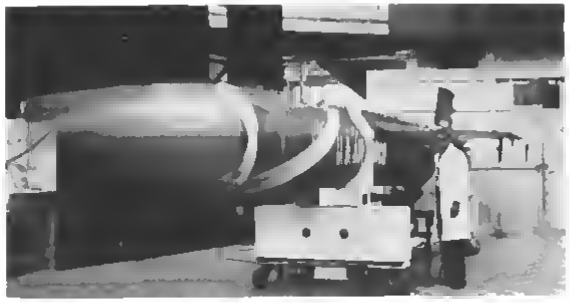
case is full, the mandrel is seated, cutting off the propellant flow. It takes about an hour to set up a unit, cast it and move it to the curing ovens.

Curing is a big problem and a new method has been developed under MIIP which has cut rejects considerably and eliminated the need for pressure curing. The new technique is called program curing and it has cut in process rejects to less than 1% with one type of motor and less than 4% with another, which is one third former rate.

Under the former method, the cast propellant was cured at a constant 170 deg. This accelerated the curing process and brought a rise in the heat of the curing reaction. Since the propellant is a good insulator, the internal areas retained heat, and the heat of reaction actually drove the internal temperature above oven temperature.

When this occurred, the oven was literally cooling the grain, and it was thermally contracting to get back down to oven temperature. The result was stressed areas and voids, especially in the curved areas and shoulders of the grain. Since the propellant was in an amorphous state, it wouldn't flow and heal these stresses and voids, according to C. I. Dunn, Process Division supervisor.

After a study of the curing process, Thiokol came up with a system of program curing which avoids this problem. Since the excessive heating occurred early in the curing cycle, the solution



Bomarc IM-99 Guidance System Tested

Guidance systems of Boeing Bomarc IM-99 missile is tested in a "soft mounted" dolly and missile exerciser. Mounts are air springs which replace davit system's leaf springs.

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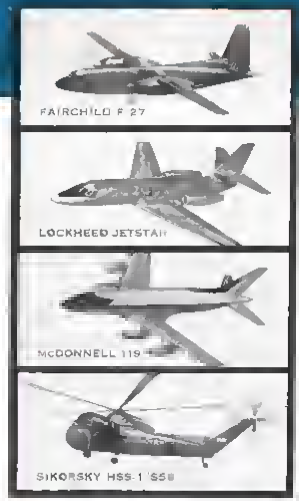

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was to program a gradual increase in temperature so the oven doesn't reach maximum temperature for several hours.

After the grain is cured, the mandrel is pulled by a hydraulic core popper and hoisted out of the engine. Such hardware as blast tubes and nozzles are installed, as are the igniters—miniature rocket motors called pyrogens which are electrically ignited by pyrotechnic pellets. When center of gravity has been determined, the solid rocket motor is painted and packed for shipping.

Before it is packed for shipping, the finished grain goes through radiological inspection. X-ray film is wrapped around the outside of the case, and Cobalt 60 pills are run through the inside of the grain to produce a picture which will show fissures. Falcon motor is photographed by 250 kv X-ray machine.

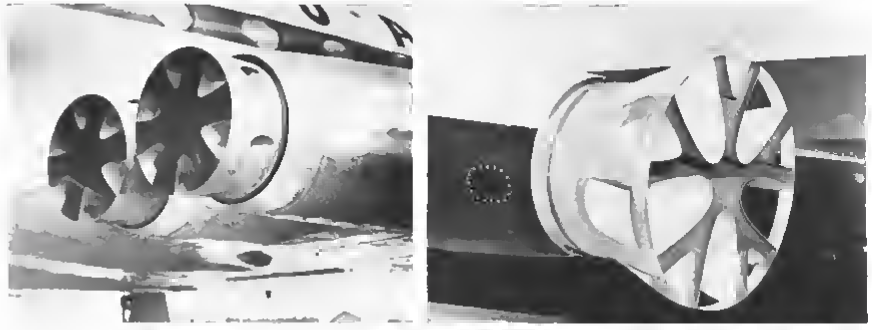
Non-Destruction Tests

Since this is an expensive process and because X-ray film may be in short supply, Thiokol investigated the state of the art in non-destructive testing in search of another method. The answer is a system of radiological inspection which produces a picture of a cross section of the grain on a television screen. Pilot equipment is planned for installation early in the coming year.

This new system is built around a 2 million electron volt Van de Graaff accelerator. A gamma ray source is positioned at the end of a shaft, and the grain is traversed over and rotated around this source. A Lumicon system gets a picture of the grain through a light amplification system which reads light from a fluorescent screen sensitive to gamma radiation. This produces a television-like picture on the monitor and permits the inspector to scan the grain as it goes by the radiation source and Lumicon pickup. Inspection can be recorded by photographing the monitor. High Voltage Engineering Corp. and Bendix Friez are building the system (AW Feb. 17, p. 59).

Finished engines are also spot checked by static test firing. Longhorn Division has a four-bay test stand which can take thrusts up to 150,000 lb. and was originally designed to handle firings of small rockets on the order of 400 pounds a day. A new two-bay pit that will handle thrusts up to 1.5 million lb. is under construction.

Longhorn Division is developing an instrumentation system for the new test stand which will use an Ampex FR100A unit to eliminate a number of electronic steps and convert transducer input directly to an FM modulated signal. FM modulation feature of the Ampex system will be used as an integrator to sum thrust/time and pressure/time relationships. Thiokol engineers are shooting for 0.25% accuracy.



NOISE suppressors for the de Havilland Comet (left) are uncomplicated and produce 4.5 db attenuation with six internal corrugations. Five deep-five-shallow nozzle (right) was simple extension of Avon-type silencer developed, tested and rejected for Conway silencing.

Turbojet Noise Suppression (Part II):

Designers Weigh Quiet vs. Cost Penalty

(This is the second of two articles on the problems and progress in turbojet noise suppression. The first article appeared in Aviation Week Dec. 29, p. 48.)

By David A. Anderton

Hucknall, England—Development of turbojet noise suppressors at Rolls-Royce Ltd. has now reached the point where:

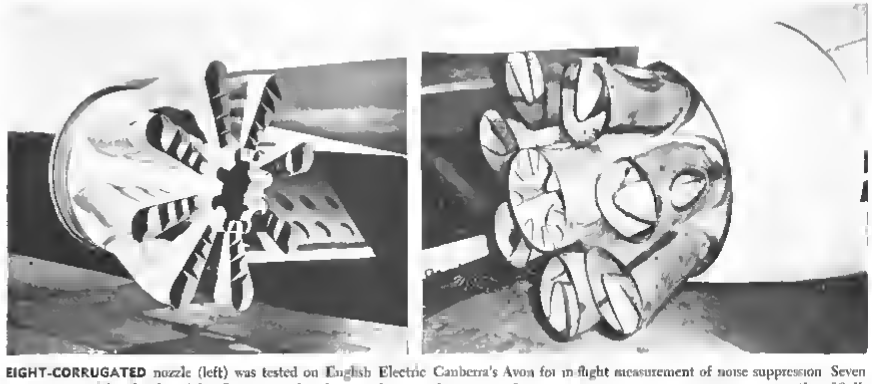
- **Units** can be designed to meet specific but reasonable silencing requirements with tolerable penalties.
- **Major design problem** is determining what losses can be borne by a prospective operator of suppressed turbojet aircraft.
- **Two silencers are in production**, one for the RA.20 Avons going in de Havilland Comet 4s, and the other for the RCo.10 Conway bypass engines scheduled for the Boeing 707-420 series.
- **The next step**—to design an engine that doesn't require silencing—is well under way in the RB.141 selected to power the D.H.121 future short-range jet for British European Airways.

Development Program

Behind this current status is a long and costly development program stretching back over several years and involving thousands of tests in ground rigs and in flight.

Rolls-Royce is not alone in this field, but it was certainly early. Engineers working in this triple-skill area—where aerodynamics, thermodynamics and acoustics are needed to solve the problems—automatically associate the name of L. B. Greatrex, head of the experimental station here, with pioneering work in noise suppression. Some technicians in sound suppression use his name as a verb, meaning "to apply his design ideas to a silencer problem" and speak of "greatrexing a new nozzle."

Currently almost every turbojet engine manufacturer and some airframe companies are studying and developing noise suppressors. With many of these



EIGHT-CORRUGATED nozzle (left) was tested on English Electric Canberra's Avon for in-flight measurement of noise suppression. Seven lobed nozzle (right) developed for Conway produced most silencing of units tested in program; maximum attenuation was more than 10 db.

companies highly competitive for commercial orders there has been some reluctance to trade information, and there has been duplication in the field.

But Rolls Royce and Boeing Airplane Co. have an agreement for complete interchange of technical data on noise suppression. Both companies follow a similar approach which differs only in design detail.

One result of this is that Rolls Royce has specific data on the noise produced by a competitor's engines: the JT3C (J57) and JT4A (J75) turbojet produced by Pratt & Whitney.

This data indicates that the Avon is the quietest of the four engines currently being silenced. The Conway runs about five to six decibles higher; the JT4A noise is between one and two decibels above the Conway and the JT3C is loudest at one to two decibels more.

Thus the JT3C powered Boeing 707-120s now in service with Pan American World Airways are 7-10 db louder than the Avon powered Comet 4s in service with British Overseas Airways Corp.

Normally a silencer that quiets the bellow of a turbojet by about 10 db can be considered a good unit. This Boeing, tackling an engine already louder by that amount has a more difficult job to do than Rolls Royce, considering only the degree of sound suppression necessary.

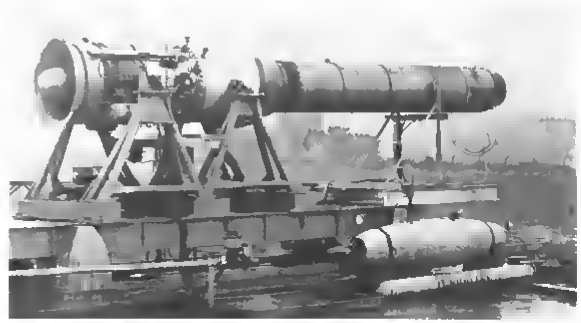
Another result of the Rolls Royce interchange with Boeing is the division of development and manufacturing of silencers for Boeing's 707 series. Rolls-Royce will develop and build the units for the Conways and Boeing will develop and build the silencers to be fitted to the J13 and JT4 engines.

Major Contributions

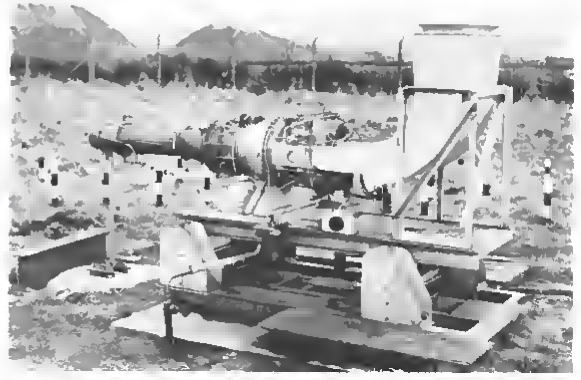
Greatrex credits engineers at the Fairey Aviation Co., developer of the Rotodyne VTOL airliner (AW Oct. 6, p. 42), with exceptional work in the field of sound suppression. He points out that the penalties attached to Fairey's silencers for the Rotodyne's afterburning tip jets are much greater than those for statically-mounted turbojets.

Fairey's problem is to produce a suppressor which lowers the noise level by an average of 10 db, and up to 15 db in the middle frequency range. Such a silencer must also take the loads applied by a 350G centrifugal force and by burning gases at about 3,200F and 45 psi. The weight has to be a minimum because blade loads must be reduced and flutter must be avoided. Besides all this the Rotodyne spends most of its flight regime in the autogyro phase, with only 5-10% spent with tip jets burning. Thus cold drag of the silencer is vitally important.

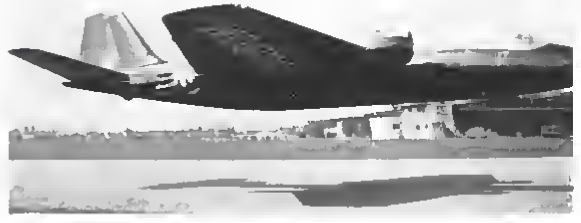
In spite of all this, Fairey technicians



ROLLS-ROYCE "siege gun" is an outdoor test stand for open-air measurements on full-scale engines such as the Avon running here. The test stand can handle thrusts up to 30,000 lb. either in forward or reverse thrust. Control room 75 ft. away is in line with the inlet.



QUARTER-SCALE test bed used by Rolls-Royce has a Blackburn Palas 600 engine producing a jet velocity of 1,760 fps. The turbojet's exhaust has characteristics comparable to full scale units and is useful for development work on scaled down silencers.



ENGLISH ELECTRIC Canberra, with Boeing type multi-tube suppressor on right engine, flies low in non-standard test. Standard altitude for flight test measurements is 500 ft. Canberra makes flights alternately on right and left engine past a measuring point on the ground.

have developed a suppressor which reduces the noise by about 4 db, with somewhat higher figures in the middle-frequency range. They expect to get 6 db from the same basic unit almost immediately, and ultimately to get 10 db or better.

Douglas Aircraft Co., although buying the Rolls Royce Conway engines for some of its DC-8 overwater versions, has developed its own ejector type of silencer and thrust reverser which will be on production airplanes. The prototype DC-8 flew with a copy of the Rolls-Royce silencer.

General Electric Co.'s Aircraft Gas Turbine Division has developed noise suppressors for the CJ-805 (J79) engines scheduled for Convair's 880 series of jet transports.

This adds a total of seven production-type suppressors which all stem from one basic design principle arising out of the characteristics of the noise itself.

Noise Mechanism

Turbojet noise is generated by turbulence at the mixing surface between the hot, high-velocity jet and the cold low-velocity ambient air. Classical mathematical analysis of the problem was performed by Prof. M. J. Lighthill in England, who delivered a formula for the variation of acoustic power.

His dimensional analysis showed that acoustic power is a function of the jet density, the cube of the jet velocity, the nozzle cross-section area, the density ratio of a jet to ambient air, and the jet Mach number raised to some power between five and seven. Since jet velocity occurs in the numerator of the ratio expressing the jet Mach number, the major factor in determining acoustic power is jet velocity.

The acoustic power generated by a jet is therefore proportional to the eighth to tenth power of the jet velocity.

The thrust of the jet is also proportional to the velocity, but only to the first power.

So the important thing to do is to reduce the velocity far enough to drop the acoustic power substantially, but not far enough to reduce the thrust too much.

For example, a jet velocity reduction of 100 fps—a few per cent of a typical exhaust velocity of 1,800 fps—results in an acoustic power reduction of just about 40% and a thrust reduction of about 5½%.

Such a thrust loss is unacceptable to an operator, who would expect the maximum to be held at 1%. For that loss the acoustic power is reduced only by about 8%, which is probably also unacceptable.

The designer's task is a difficult one. He must provide maximum noise suppression with minimum reduction in

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The U.S. Army's new Q-5 *Kingfisher* was designed by Lockheed's Missile Systems Division to provide our mighty arsenal of ground-to-air missiles with a realistic test of marksmanship—against high-altitude targets moving at supersonic speeds over 1500 miles-per-hour.

The *Kingfisher* is 38-feet long, 20-inches in diameter, has a 10-foot wingspan and weighs more than 7600 pounds. As it flashes across the skies it electronically simulates any desired size and type of "enemy" plane or air-breathing missile.

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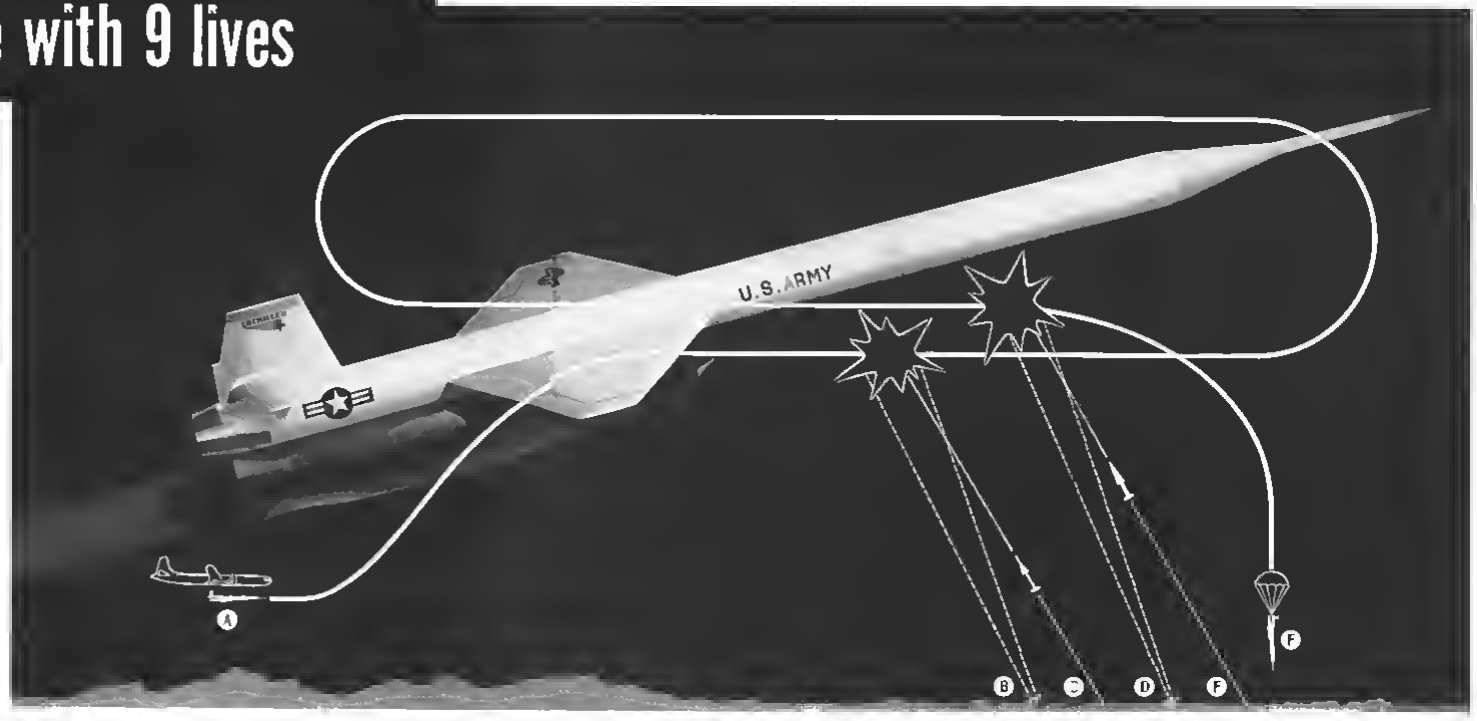
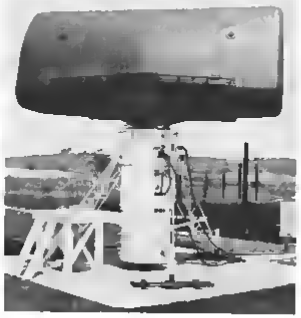
Undamaged by "hits" scored on its electronic image, the Q-5 *Kingfisher* is parachute recovered after each flight.

This Lockheed-developed "missile with 9 lives" will enable the U.S. Army to achieve hitherto impossible proficiency in missile marksmanship against supersonic targets—at a saving to taxpayers of approximately half a million dollars on each recovery flight.

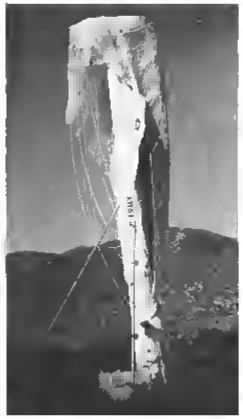


Q-5 is dropped by plane at 35,000 feet ((A] in diagram). Then its twin rockets ignite, propel it to speeds required to operate its ramjet engine.

Q-5 is detected as "enemy" by ground radar (B], and its speed, altitude, and course are fed into fire-control computer of Nike battery.



Missiles fired at Q-5 are like those used in wartime—but lack high-explosive warheads. Nike missile (C) scores "hit" on Q-5's electronic image.



Above: Entering oval flight pattern, Q-5 attains speeds over 1500 mph. Second ground radar (D] and missile-launching battery (E] practice their marksmanship until Q-5 *Kingfisher's* fuel supply is exhausted.

Left: Landing on its nose-spike in a remote, uninhabited area, after floating down by parachute (F), the Q-5 is recovered by U.S. Army ground crews—to be refueled and refitted for future flights.

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jet thrust and minimum [illegible] in weight and nacelle drag.

He ends up producing a piece of hardware for the airplane that contributes absolutely nothing to the economy of the airplane's operation or the safety and comfort of the passengers.

Current silencers work by speeding up the mixing of the hot high-velocity jet with the ambient air and by spreading this mixing over a large area. They do this in several ways:

- By corrugations or lobes inside the exhaust nozzle, as in the Rolls Royce silencers for the Avon.
- By a large number of small nozzles in an array, as in Boeing's silencers for the Pratt & Whitney engines.
- By a lobed nozzle looking like a large flower, as in the Rolls-Royce silencer for the Conway engine.
- By an ejector arrangement, as in Douglas' silencers for the DC-8.

Specific Silencers

The unit built by Rolls-Royce for the Avon engines in the Comets is deceptively simple in appearance. It produces a peak-to-peak sound attenuation of about four or five decibels, which is enough to reduce the roar of the engines to a tolerable level.

The silencer is a relatively simple extension to the jet tailpipe. Area distribution along the axis produces a convergent-divergent nozzle. But built in the interior surface of this extension is a series of six lobes which Rolls-Royce refers to as corrugations from their earlier work with internally-corrugated nozzles. Each of these corrugations is pressure balanced across its wall by a bleed tube leading to ambient air.

Increase in cross-sectional area over that of the standard nozzle is small, the area ratio is 1.57, which means that the silencer diameter is 1.25 times as great as the unsuppressed nozzle.

No thrust reverser is included in this configuration, because of the Comet's landing performance.

The Conway is more of a problem to silence than the Avon; it makes more noise. This is incidentally, in contrast to one of the early arguments advanced in favor of the bypass engine; it is supposed to be a quieter engine. It can be, thrust for thrust, but this one is not.

The reason is that the Conway produces more thrust from a larger nozzle with somewhat colder jet exhaust. Lighthill's dimensional analysis showed that jet noise—although dominated by the factor of jet velocity—also is a direct function of jet density and cross section area. The Conway uses a cooler jet with higher density and a larger cross-sectional area; these factors combine to raise the sound level of the engine.

Using generalized performance curves developed by tests and analysis, Rolls-Royce engineers were able to select the correct parameters for the desired silencing, which was on the order of 10 db. Three suppressors were constructed for comparative tests:

- **Five-deep-five-shallow nozzle**, which mounted 10 corrugations inside a single circular nozzle. Area ratio of this nozzle was 2.72, diameter ratio therefore was 1.65.
- **Eight-corrugated nozzle**, which had eight vaned lobes symmetrically oriented around a central nozzle with eight corrugations and which resembled a large steel daisy. Area ratio was 2.74, diameter ratio was about 1.66.
- **Seven-lobed nozzle**, which had a central nozzle with seven internal corrugations surrounded by seven separate egg-shaped nozzles each with a single internal corrugation. Area ratio was 2.60, diameter ratio was 1.61.

Each of these nozzles was tested in comparison with an Avon type (six-corrugated) nozzle and an unsuppressed standard nozzle.

Quietest combination was achieved with the seven lobed nozzle and noisiest of the three was the eight corrugated unit. Maximum attenuation was on the order of 10 to 11 db compared with the unsuppressed unit, and the spread between noisiest and quietest was about 3 db.

Like most engineering decisions, the final choice of suppressor design was not made on the basis of silencing only. Weight, drag, and internal losses were factored into the final choice.

Best compromise was decided to be the eight corrugated unit. Its peak to peak attenuation in ground tests was about 8 db. But in the critical flight tests the attenuation increased to between 10 and 11 db, more than enough to meet the technical requirements and probably quite enough to make subjective noise acceptable.

The company treats these silencers—and will in future units—as parts of the engine unit to be pampered or handled any more carefully than the engine itself. Overhaul life is stated to be the same as that of the engine which means 1,000 hr. initial period for the Avon silencers.

Test Background

Both model and full scale ground and flight tests have been made by Rolls-Royce technicians during the company's sound suppression program. They started originally with a simple open air arrangement in which sound measurements were taken in the open at specified distances and angles from the nozzle of a turbojet. This had the advantage of being quick and simple, it had the disadvantage of supplying only static ground data.

That disadvantage plus some of the estimates of future needs made the

engineers take a second look at their test rig. The static open air arrangement, for example, could give no aerodynamic data which could be interpreted in terms of airplane performance measurement. It was expensive to run a full-scale engine and would get more expensive as future measurements were made more extensively on larger engines. Probably most important, it gave no indication of flight attenuation.

Three objectives came out of this detailed consideration:

- **Accurate measurement** was the most important factor. Without detailed measurements and knowledge of their validity, data was useless.
- **Small-scale experiments,** if they could be scaled up without error, would save time, money and material.
- **Flight tests** were a necessity.

Rolls-Royce now has three silencing test beds on the premises here:

- **Full-scale engine rig,** the company's 'siege gun,' which can handle thrusts up to 30,000 lb.—either in forward or reverse thrust. Free distance around the engine is on a sector of 200 ft. radius and 240 deg. included angle centered on the engine nozzle. A control room 75 ft. away is in line with the inlet. Accuracy of repeated thrust measurements is ±0.25%. The need for accuracies of this level or better is emphasized by the fact that desirable thrust losses—in terms of what the engineers think the operators will bear—are 1% or less.
- **Quarter-scale test bed,** using a Blackburn Palas 600 engine producing a jet velocity of 1,760 fps. This is somewhat under contemporary high-thrust engine standards, but close enough to give comparative data on scaled down nozzle configurations.
- **English Electric Canberra** fitted as a flying test bed with silencers on one engine only. This twin-Avon airplane, which can be flown easily on one engine, is used to make flights alternately on the left and right engine alone past a measuring point on the ground. This procedure gives in-flight data for a single suppressed and a single unsuppressed engine, so direct comparisons can be made between successive passes of the airplane under the same control conditions. The standard altitude for Canberra flight-test measurements is 500 ft.

Some of the tests made by Rolls-Royce engineers have shown a few interesting and even unexpected results from some expected problems. For example, what about the noise generated by two engines close together, like the Comet installation? Is it twice as much, or more, or less? What about reflection or augmentation of noise from parts of the airplane structure, such as the underwing surface of an airplane powered by pylon-mounted jets?

For a Comet type of installation where two engines are mounted closely together, the noise in the plane of the twin exhausts is actually reduced by about three decibels when the tailpipes are tangent. As the spacing opens out to four diameters or more, the attenuation drops off rather rapidly.

But this is for the unsilenced jet. With silencers only small portions of the twin jets would be adjacent, and the overall silencing effect would probably be insignificant.

As for reflected noise, there seems to be no problem there. Tests made with varying areas and thickness of skin showed no change in peak attenuations.

One of the more interesting aspects of the test results was the measured difference between noise on the ground and noise in the air for different types of silencers. Sound pressure levels were plotted against relative velocity—that is, the jet exhaust velocity minus the airplane flight speed. Thus a low relative velocity is a high-speed flypast and vice versa.

Data Points Curve

For an 1,800 fps. relative velocity, which is probably a fair figure to use for climbout performance of a modern transport, data points for in-flight attenuation and ground attenuation did not lie on a straight 45-deg. line, but rather on a curve. Furthermore, the in-flight attenuation was greater than that of the ground values by almost five decibels for the eight-corrugated nozzle chosen for the Conway.

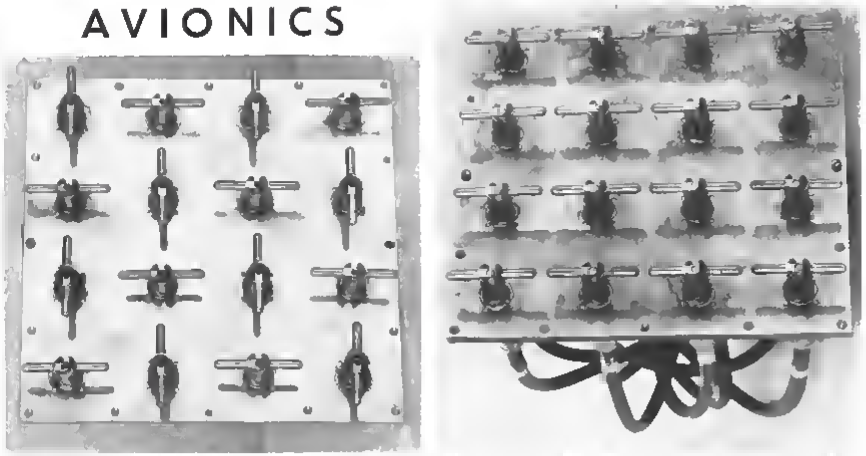
This may be, says Rolls-Royce, because the relative velocity should actually be that between the jet exhaust and the local stream velocity around the silencer inlet, instead of free stream values.

What does all this cost? What are the losses to be charged against the suppressor itself in weight, drag, thrust and specific fuel consumption?

Greatrex says Rolls-Royce settled on an arbitrary figure of 1% for each of these variables. The sound suppressor could not increase cruise specific fuel consumption by more than 1%, decrease the takeoff thrust by more than 1%, increase the weight of the airplane by more than 1% of the total pounds of takeoff thrust and increase the cruise external drag by over 1% of the total net thrust in cruise and configuration.

These 1% increments, applied to an airplane that is takeoff limited, cost the operator somewhere between 1 and 2% each in payload. Final cost for suppression between 4 and 8% of the airplane payload. This means anything from half a dozen to a dozen passengers in high-density loaded jets.

Such penalties are just bearable in the first generation of jet transports, says Greatrex. But there are operators who would argue long and loudly with him.



TWO MODELS of four by four Van Atta arrays each mounting 16 dipoles. Array at right with dipole axes aligned when illuminated by a test source with the polarization parallel to the dipole axes showed echo area reduction of only 3 db from minus 30 deg to plus 30 deg of broadside. This array is polarization sensitive. Crossed dipole array at left is polarization insensitive but echo area is less

Compact Reflector Has ECM Potential

By James A. Fusca

Rome, N. Y.—A new type of reflective antenna array that operates over much wider angles of incidence than the conventional corner reflector has been tested here at the Air Force's Rome Air Development Center laboratories.

The technique could be used in applications ranging from electronic countermeasures and air traffic control of light aircraft to space communications relay satellites.

Called the Van Atta array after Dr. L. C. Van Atta of Hughes Aircraft Co. who first proposed it, the reflector technique is based on the equal interconnection of the radiators of an antenna array so that received energy is reradiated in the direction of arrival at any angle from broadside to endfire.

Additional Advantages

Additional advantages include the possibility of production of such arrays by printed circuit and stripline techniques for lightness and simplicity and of varying the geometry of the radiating elements to achieve bandwidths theoretically as high as 10 to one.

Diversionary missiles such as the surface-to-air Gonse (AW Dec. 22, p. 27) and the air-to-air Quail (AW Dec. 1, p. 31) will among other electronic countermeasures techniques, attempt to confuse enemy radars by providing a strongly enhanced return signal. Radar reflectors that increase the apparent radar cross section of the diversionary drone can make it appear to be a large bomber.

During World War II clusters of corner reflectors were used to obtain this type of radar signal enhancement. Corner reflectors, however, have the disadvantages of being bulky, requiring rigid support to maintain within close tolerance the angle of intersection of their planes and are very sensitive to the angle of incidence of the energy to be reflected.

For these reasons the simplicity and versatility that appear to be the advantages of the Van Atta technique indicate a possibility of using it in this type of application. Similarly, it could be used to increase the apparent radar cross section of light private aircraft which presently cannot be seen by air traffic control radars, simplifying air traffic control of such aircraft and aiding collision prevention.

Third Use

A third possible use of the technique would be as a reflector to be mounted on a permanent communications relay satellite (AW Oct. 20, p. 85) such as is presently under study by the Air Force. Four satellite relay stations orbiting the earth around the equator at an altitude of 22,300 mi. would maintain fixed positions relative to the earth as the earth rotated. By spacing these satellites at intervals of 90 deg. longitude, it would be possible to relay a message completely around the earth. One of the extremely difficult problems however, is that of stabilizing the satellite's attitude to within one-quarter degree if a highly directive reflector such as a flat plate (mirror type) is used. The aperture of a Van Atta type of reflective array would be large enough to solve this problem.

Theory of Operation

The test program at Rome Air Development Center was undertaken to verify the concepts proposed by Dr. Van Atta by which the radiating elements of an antenna array might be interconnected to reradiate received energy back in the direction of arrival. The program is described in RADC Document No. AD-148684, dated April, 1958.

This type of reflective array can take the physical form of a linear or planar array. The capability of reradiating energy incident upon the array at any angle from broadside to endfire is limited only by the directivity of the radiators used.

The theory of operation of a Van Atta array can be seen from the example of a linear array of six equally spaced radiators interconnected with equal line lengths. The radiators are interconnected in pairs that are equally spaced about the array center. Lines of equal length are used to make the interconnections because it is of the utmost importance that equal phase delay occurs in all the lines.

A plane wave incident upon the array induces currents of relative phase in each of the individual radiators. The energy travels through the connecting lines and is reradiated with the relative phase maintained because the same phase delay is incurred through each line.

Relative Phases

These relative phases, however, are transposed about the center of the array and a plane wave is transmitted back in the direction of arrival.

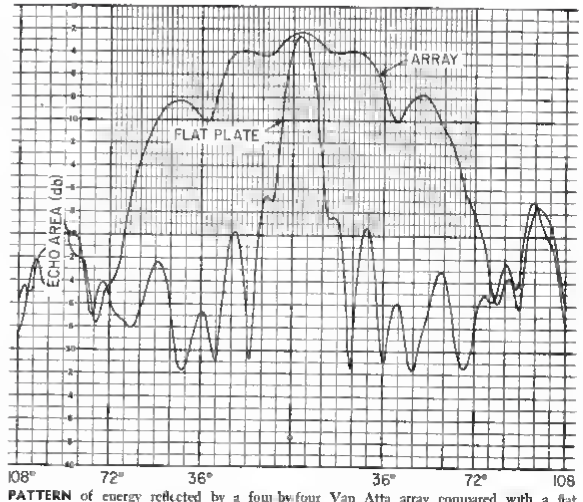
In the same manner, a two dimensional array can be made up in the form of a four by four element array with the elements interconnected in pairs symmetrically about the center of the array that will exhibit the same type of performance.

Because no experimental models of this type of antenna array were known to exist, Rome engineers undertook the construction and testing of one. A four by four array of 16 dipoles was selected.

The dipoles were mounted one quarter wave above a ground plane and were spaced 0.6 wavelengths apart at the selected frequency of 2,850 mc.

Echo Measurement

Measurements of the echo area of the Van Atta array were made as a function of the angle of incidence and were compared with measurements made on a flat conducting plate of the same cross section which was used to establish an echo area reference level.



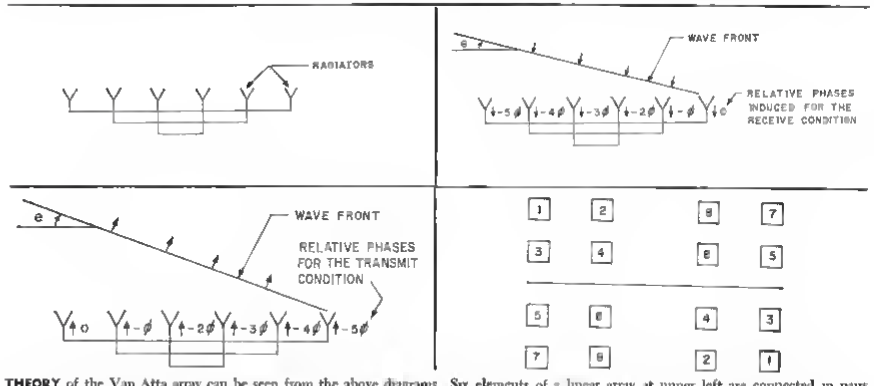
PATTERN of energy reflected by a four by four Van Atta array compared with a flat plate of the same cross section versus angle of incidence. Array had dipole axes aligned and polarization of the incident energy was parallel to dipole axes

To determine polarization effects and frequency sensitivity, measurements were made with the plane of polarization of the signal from the test source parallel to the dipole axes, at 45 deg. and normal to the dipole axes, and at frequencies up to 350 mc. higher than the cut frequency.

The results of the measurements showed that at broadside the echo area of the array and the flat plate were approximately equal, as was predicted by the theory. The echo area drops off 3 db at angles from broadside of about plus or minus 30 deg. and 10 db at angles of about plus or minus 55 deg.

This indicates that the wide angle capability of the Van Atta array as tested is significantly better than that of a corner reflector where the 3 db point usually occurs at angles of plus or minus 20 deg. and 10 db at plus or minus 30 deg.

Patterns measured with the incident



THEORY of the Van Atta array can be seen from the above diagrams. Six elements of a linear array at upper left are connected in pairs with equal line lengths. Plane wave incident upon the array (upper right) induces currents of relative phase in each element which travel through the connecting lines and are reradiated with the relative phases transposed about the center of the array, so that a plane wave is transmitted in the direction of arrival. Interconnections of a four by four two-dimensional array are shown at lower right.

polarization rotated 45 and 90 deg with respect to the axes of the dipoles showed, as expected, that this array was polarization sensitive. The echo area drops off 10 db, for the 45 deg rotation of polarization, and with crossed polarization the array acts as a flat plate.

To overcome the polarization sensitivity, a crossed dipole array was constructed. Measurements of the echo area of this array showed that it was polarization insensitive, but that the echo area was less than that of the first array.

Echo Area

As can be derived from the formulae of the theory, the echo area of the Van Atta array is proportional to the square of the array gain when phased to direct a beam at the angle of interest. The gain of a phased array is approximately proportional to the cosine of the angle from broadside, but this approximation is not valid for large angles from broadside.

Therefore, the echo area of this type of array is approximately proportional to the square of the cosine of the angle from broadside.

Based on this approximation, the echo area of the constructed array should drop 1.2 db at angles of plus or minus 30 deg and 3 db at angles of plus or minus 45 deg. The measured area, however, dropped about twice this amount. The directivity of the dipoles mounted one-quarter wave above the ground plane causes the echo area to drop at wide angles from broadside especially at the endfire condition where their directivity is zero.

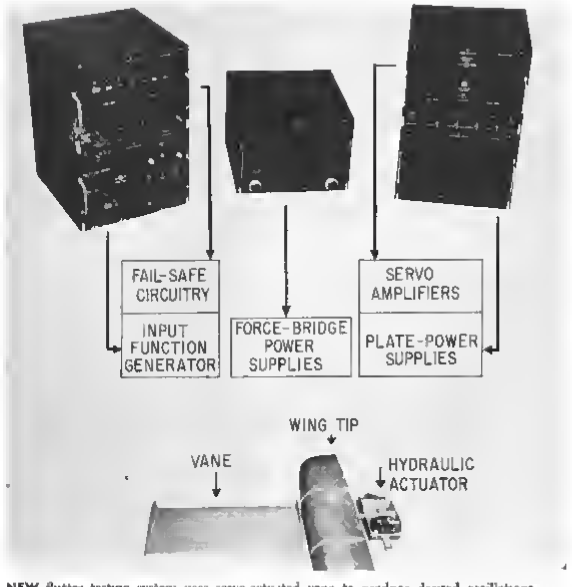
Test Conclusions

The test program is considered to have substantiated the theory of the array.

With the type of array constructed for the tests, limitations as to frequency band, polarization, and directivity of radiators were found but the polarization sensitivity can be overcome by using crossed dipoles or a circularly polarized radiating element such as a helix or flat spiral.

The helix and flat spiral also would provide a broader bandwidth. The theory applying to these elements as radiators suggests that a bandwidth of 10 to one could be achieved with a helix and a bandwidth of five to one with a flat spiral.

Because this type of array could be produced by printed circuit techniques where, for example, dipoles or flat spirals would be deposited on one side of a dielectric sheet and the interconnecting lines on the other side, it offers the possibility of rapid and inexpensive manufacture, which would be a considerable advantage for civilian applications.



NEW flutter testing system uses servo-actuated vane to produce desired oscillations.

Unit Simulates Flutter Conditions

Los Angeles—New system designed to speed flutter testing of new aircraft by providing a convenient means of introducing a wide variety of flutter conditions has been developed by ElectroSystems, Inc., Division of Royal Industries Inc. The system has been successfully used on our of new U S jet transports, the company reports.

System employs a small control vane attached to the wing tip, which can be deflected through any desired amplitude at any desired frequency by means of electro-hydraulic servo system operated from control console by a flight test engineer. Control vane can be programmed to deliver transients as well as steady state and swept frequency forces, according to the company.

Control vane oscillation frequency can be swept through a wide band of frequencies automatically until the critical mode is detected by instrumentation. Then manual control is used to adjust the frequency until the wing is brought up close to its natural mode. The device may be suddenly stopped to permit observation of the decay response from which structure damping can be determined.

As a safety feature, the operator can pre-set safe limits of wing flutter velocity, aerodynamic force or servo error. If conditions exceed these values, the hydraulic actuator is bypassed allowing the control vane to become free, moving into a neutral position, and a red warning light flashes to the operator.

The system includes control vane and actuator, with mounting adaptor and special fairing; the electro-hydraulic servo system and hydraulic power supply; amplitude and frequency program timing console, and safety interlock controls.

ElectroSystems says it is developing a miniaturized version of the in-flight flutter excitation system for use in testing military aircraft where available space, weight are more restricted. Company's address is 1035 Westminster Ave., Alhambra, Calif.

FILTER CENTER

▶**The Winner: Heathkit**—Avionic subsystem bidders for North American Aviation F-108 and B-70 generally agree that North American has been extremely tight-lipped about revealing who's ahead in subsystem contractor evaluations. When eager bidders seek some indication of evaluation standings prior to official announcement North American's stock answer is "Heathkit's ahead." (Heathkit, a division of Daystrom, produces hi-fi instruments and other electronic equipment in kit form for home assembly.)

▶**Loran-C Contract to Collins**—Coast Guard will soon announce award of contract to Collins Radio Co. for further development of Loran-C (sometimes called C-tac) and for fabrication of prototype systems. The accurate, long-frequency hyperbolic area coverage navigation system, like British Decca, can be used both by ships and aircraft. System originally was developed by Sperry Gyroscope under Air Force sponsorship (AW April, 1957, p. 101.)

▶**Ground-Air Meteor Burst System**—General Electric's Light Military Electronics Department is working on a ground-to-air and air-to-ground data link system which utilizes meteor burst communications system techniques (AW June 17, 1957, p. 96). System may include a propagation frequency evaluation to automatically select optimum frequency.

▶**Hot Semiconductor Conference**—Conference on high temperature silicon carbide semiconductors will be held in Boston April 2-3, sponsored by Air Force Cambridge Research Center. Some 50 leading scientists working in silicon carbide, from U. S. and other countries will attend on a "by invitation only" basis. Conference chairman is Joseph R. O'Connor of AFCRC's Electronics Research Directorate.

▶**Signed on Dotted Line**—Contract awards recently announced by avionics manufacturers include the following:

- **Canadian Marconi Co.**, Montreal, reports orders from Pan American World Airways for six Doppler radars for use in Boeing 707-121s. Canadian Doppler radar weighs less than 70 lb.
- **Wilcox Electric Co.**, Kansas City, reports that Trans World Airlines will equip all its new jet transports with Wilcox Model 714B air traffic control (radar) transponders.
- **Consolidated Airborne Systems**, Minola, N. Y., $1.25 million from Gentile Air Force Depot for modernizing USAF's M-5 tachometer tester and for production of TTU-27/F tester, developed by Consolidated, which will supersede M-5 for field testing.
- **Microwave Associates, Inc.**, $100,000 award for tunable capacitance microwave silicon varactors from Army Signal Supply Agency. Device can be used as low noise microwave amplifier, harmonic generator and frequency converter.

USAF Tests Synthetic Hydraulic Fluids

By Michael Yaffee

New York—Need for high temperature hydraulic fluids in advanced aircraft and spacecraft is being met by the development of synthetic chemical compounds for operation in the 400-1,000F range.

The first 400F fluid has been qualified under Air Force specification Mil-H-8446A and will be used in the hydraulic system of the Convair B-58. Designated MLO-8515, it is a blend of 85% disiloxane ester and 15% dioctyl sebacate, which was developed by California Research Corp. under Air Force contract and is being marketed by Oronite Chemical Co. Other synthetic fluids are expected to qualify under this specification in the near future.

Meanwhile, researchers at Wright Air Development Center are pushing ahead with the evaluation of synthetic hydraulic fluids for operation at 550F and 700F. Republic Aviation Corp., working under Air Force contract 33(616)-5117, has completed Phase I on research and development of a complete hydraulic system to operate at 1,000F. Republic has been working on a continuation of Phase I and hopes to enter Phase II and start actual hardware development this year.

Temperatures Rise

The quest for high temperature hydraulic fluid is closely tied to Air Force's search for high temperature lubricants (AW Sept. 29, p. 51). The requirements for both have been created by the advent of high speed military aircraft.

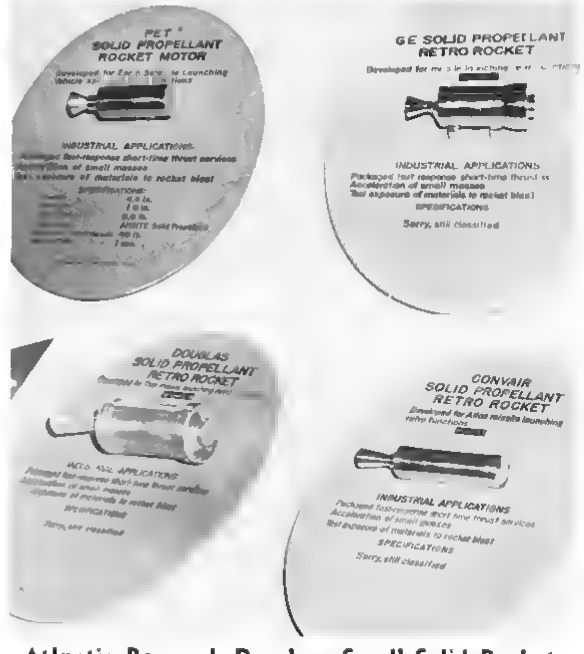
As flying speeds go higher, ambient air and aircraft operating temperatures rise. Up to Mach 2, the rises are gradual and are not too difficult to cope with. But thereafter the curve steepens sharply and the problems become critical. Temperature, too, is a function of the amount of work that has to be done, and over the past few years, the amount of work that aircraft hydraulic systems must do has been increased.

High temperature problems also increase with flight duration, making the situation more difficult for bombers than for fighters. Temperatures in hydraulic systems generally tend to go higher than those in lubrication systems because hydraulic actuators must be placed as close to the components they control as possible.

As a result, they often are located in the hottest areas of the vehicle, such as leading edges, and in the near future, next to gimbaled rocket motors where temperatures run to thousands of degrees.

Another type of problem occurs in hydraulic actuators which operate components such as speed brakes located on the aircraft fuselage, near the afterburner. Here, the hydraulic fluid is subjected to high temperatures which go much higher because the brakes are operated only intermittently and fluid becomes stagnant.

The Century series of aircraft is able to operate successfully with petroleum-based hydraulic fluids which serve satisfactorily up to 275F. The B-58 is not. Its hydraulic system operates at 350F with spot temperatures as high as 500F for brief periods necessitating the development of a



Atlantic Research Develops Small Solid Rockets

Atlantic Research Corp. has developed small solid propellant rockets for space technology functions. Rocket at upper left was developed for earth satellite launching vehicle spin and retro functions for PET (Propulsion, Experimental Test). Specifications are: length, 4.8 in.; diameter, 1.5 in.; total weight 0.6 lb.; propellant, ARCITE solid propellant; nominal thrust (sea level), 40 lb.; action time, 1 sec. Unit at upper right was developed for General Electric for missile launching retro functions. Rocket at lower left was developed for Douglas for Thor missile launching retro functions. Unit at lower right was developed for Convair Atlas missile launching retro functions. Atlantic Research says the rockets have the following industrial applications: Provide packaged fast response, short time thrust services, accelerate small masses, and can be used to test exposure of materials to rocket blast.

400F hydraulic fluid. It is believed that the hydraulic systems of the North American B-70 and other Mach 3 aircraft will operate at temperatures of 400-450F and will need at least a 500F hydraulic fluid. Requirements of the Dyna Soar and similar vehicles are expected to jump to 1,000F as the upper temperature capability for hydraulic fluids.

Cooling Devices

Up to a point, it is possible to design around the problem by including such things as heat exchangers or some other cooling device which might enable the aircraft to fly with existing hydraulic fluids. In one case, coolant is actually circulated through hydraulic actuators to keep stagnant brake fluid from becoming too hot. But this only puts off the problem and results in complicated and weighty designs which are more vulnerable to failure and which penalize high speed aircraft performance severely. Moreover, there is a limit beyond which cooling schemes are of little value. The hydraulic systems of the B-58 and Republic F-103 are cooled down, for example, yet both still require the use of new, high temperature synthetic fluids. To avoid these problems, the Air Force wants and needs hydraulic fluids that will operate satisfactorily at high temperatures without cooling.

The missile picture is somewhat different. Although temperatures in the hydraulic system may hit 1,000F or more, thermal lags are long enough and flight times short enough so that most missiles are still able to operate satisfactorily with presently available hydraulic fluids. Undoubtedly, all missiles soon will also require higher temperature hydraulic fluids. But because the problem here is less pressing it has been put off. And as a result, says one hydraulics expert, researchers actually know very little at present about the high temperature hydraulic requirements of missiles.

Temperature Ranges

For the present, Air Force has divided its hydraulic requirements into five temperature groupings. The hydraulic systems for each group are designated as follows:

- **Type I.** Temperature range for this system is −65 to 160F. A number of petroleum base oils have been qualified as Type I hydraulic fluids.
- **Type II.** Temperature range for Type II systems is −65 to 275F. Fluid specifications covering this group have been met by petroleum base oils.
- **Type III.** This is the first type hydraulic system to require synthetic fluids. To date only one has qualified. Temperature range is −65 to 400F.
- **Type IV.** No specification yet exists

for this group. Tentative temperature range is —65 to 550F. These fluids are expected to be synthetics. The requirement for Type IV hydraulic fluids is estimated to be one to three years away.

• Type V. No specification has been established for this group, temperature range is tentatively set at —65 to 700F. It also is expected to use synthetics. Time requirement is estimated at two to four years from now. Types IV and V are only tentative targets and may well merge into one group as the hydraulic program progresses.

Although not officially tagged as Type VI, there is a sixth group. This is the 1,000F hydraulic system. The tentative temperature range set for this system is 20 to 1,000F but may turn out to be somewhat narrower. Researchers in this area say they will settle for hydraulic fluids that will operate at any temperature significantly above—and this is defined as 50 deg. or more—700F.

Consensus as to the time when 1,000F hydraulic fluids will first be needed is five years from now. Most promising candidates for this group at present are also synthetic compounds. But this range from 750F on is definitely still open territory and many researchers believe that the natural petroleum base materials have as good a chance as the synthetics of claiming it.

Nuclear Field

There is another group of fluids that is being developed for use in nuclear powered aircraft. While this is a separate program from that of the high temperature hydraulic fluids, the two do overlap to some degree. Radiation resistant fluid will probably have to operate in high temperature environments, although not a primary goal or a requisite of any order, radiation resistance would be welcomed as a secondary characteristic in high temperature hydraulic fluids. More significant, from results to date, it appears that the most promising radiation resistant fluid is also one of the more promising materials for application in the 750 to 1,000F range.

Within each high temperature hydraulic fluid grouping, the Air Force is looking principally for materials that remain thermally stable over the designated temperature range. In addition, each hydraulic fluid should have the following characteristics:

• Oxidation resistance. Although this is less of a problem in hydraulic systems, which are essentially closed, than in lubricating systems, it is still important that the fluid does not react with the oxygen in any air that may get into the system.

• Limited viscosity range. Hydraulic fluids should not vary too greatly in

viscosity over the designated temperature range. For the Type III fluids, the specification calls for a minimum viscosity of 2.5 centistokes at 400F, a maximum viscosity of 2,500 centistokes at −65F, and a −75F maximum pour point. Ideally, the Air Force would like to have a material that remained fluid from −65F to 1,000F. At present, this looks like an almost impossible goal to reach within the next few years. To get a material that is liquid at 1,000F, it may be necessary to start with the compound in a solid state at 0 deg. Moreover, imposing very low temperature requirements on hydraulic systems in the opinion of some researchers constitutes an unnecessary and possibly foolish penalty. Where there have to be penalties, says Republic engineer William Mayhew, they should be imposed on the ground and not in the air. If a good hydraulic system is developed that has a lower temperature operating limit of 20F, keep the aircraft in a heated shelter during cold weather, particularly since there is electronic equipment such as guidance and armament components, that must be maintained at 130F anyway, Mayhew contends. Other recommendations:

- **Low vapor pressure.** For Type III fluids the maximum allowed is 5 mm of mercury at 400F.
- **Low foaming.** The fluid should be able to get rid of entrained air in a short period of time.
- **High bulk modulus.** If the compressibility of a hydraulic fluid increases very much with temperature, Oronite Chemical Co.'s J. S. McClure says, the system becomes spongy and loses the ability to respond instantaneously.
- **Storage stability.** The fluid should remain ready for use after a reasonable storage period, say a year.
- **Compatibility.** Hydraulic fluids in any one group should be compatible with each other; they should not swell gasketing or sealant materials and should not corrode metals with which they come into contact. At the same time, however, it is more than likely that new alloys and elastomeric materials will have to be developed for service with very high temperature hydraulic fluids.
- **Low sludge formation.** Fluids must not form or deposit coke, sludge, resinous gums or insoluble materials either in high temperature service or in storage.
- **Low toxicity and ignitability.** The material must not be toxic either as a fluid or as a vapor, and it should possess a minimum autogeneous ignition temperature well above its intended maximum operating temperature limit.
- **Shear stability.** The ability to resist mechanical shearing forces is an important requisite for hydraulic fluids.

There are other characteristics that

will be needed in new high temperature hydraulic fluids. Among these are such things as lubricity, low wear, radiation resistance, high specific heat and heat transfer coefficient, low coefficient of expansion, low absorbency of water and low solubility in water, and low specific gravity. Already in present hydraulic fluid specifications many of these characteristics are expected to find their way into future specifications as well. Others, undoubtedly, will have to be sacrificed for expediency.

Development Status

In an attempt to meet as many of these conditions as possible, researchers with one major exception are concentrating their efforts to develop high temperature hydraulic fluids on synthetic chemicals.

The exception is the Petroleum Refining Laboratory at Pennsylvania State University. Here for the past 12 years, Drs. M. R. Fenske and F. Klaus have been carrying out a continuing study of petroleum based hydrocarbons for WADC, which is still very interested in petroleum's potential for high temperature aircraft applications both as engine oils and as hydraulic fluids.

Broken down by system types or temperature ranges, the current status of the various fluid research efforts are as follows:

Type III, −65 to 400F. To date, the only fluid in this group accepted by the Air Force is Oronite's blend of disiloxane ester and dioctyl sebacate in which oxidation and hydrolysis inhibiting additives have been incorporated.

Originally, Oronite offered the Air Force just the plain disiloxane ester. In testing the material, WADC researchers were surprised to find that, unlike most hydraulic fluids which caused gaskets and seals to swell too much, the Oronite product did not cause the elastomeric materials to swell enough. To correct this condition, WADC added the dioctyl sebacate.

As a group, the organic silicate ester base fluids look promising, according to McClure and it is estimated that they will be used extensively over the next 10 years in this temperature range or even beyond. The development of suitable pumps and elastomers for higher temperature operation, says McClure, must be a concurrent achievement and may prove more difficult than the development of higher temperature hydraulic fluids.

The straight silicones possess poor steel-on-steel lubricity, McClure says, and other synthetics such as esters of dibasic acid and polyglycols do not meet Air Force requirements over the operating temperature range.

Dow Corning Corp., also working in this area, claims it has made considerable advances on the lubricity of silicones. The company says that the biggest problem at the present time is the lack of pumps that can handle high temperature fluids.

With the comparatively small amount of air that gets into a hydraulic system, Hercules believes that the high lubricity and thermal stability of its Hercolubes A and F, pentaerythritol esters of saturated fatty acids, make them strong contenders as base stocks for synthetic hydraulic fluids in this temperature range and possibly higher. Celanese Corp., working on the development of finished hydraulic fluids for service up to 500F, is also very much interested in the pentaerythritol esters.

George Baum, WADC project engineer on hydraulic fluids, says there is still some interest in the synthetic esters for application in this temperature range. However their high temperature properties, he adds, are questionable, particularly at 500F and beyond.

Type IV, −65 to about 550F. Type V, −65 to 700F. At this point, Baum declares, it is difficult to distinguish between Type IV and Type V fluids or to draw a clear line of demarcation between research in the two areas. He also points out that it may be extremely difficult to meet the Air Force's requirement for a −65F starting temperature and that there is always the possibility that Strategic Air Command and Tacti-

cal Air Command may have to accept a somewhat higher temperature, at least initially.

If a −65F low temperature requirement proves to be the case, then the silicone fluids appear to be the most likely candidates for covering the complete temperature range despite their present lubricity problems. The use of additives to improve lubricity looks promising, says Baum, and may well make the silicones serious contenders in any event.

General Electric, for example, has developed a special additive which improves the lubrication features of silicone fluids for sliding steel surfaces. It is incorporated in General Electric's Versilube 81717, a high temperature hydraulic fluid developed under the sponsorship of WADC (AW Nov. 18, 1957, p. 115). The 81717 chlorphenyl silicone fluid, according to the Air Force, is capable of efficient operation from −65F to 575F.

Meanwhile, WADC, which has the overall responsibility for the program, is carrying out in-house development on a variety of tetra-alkylsilanes which are being considered for use up to 700F. WADC is also looking at some mineral oil blends prepared by PRL's Lenske and Klaus, that have never been available before. For potential application at the 700F level these blends approach the maximum theoretical thermal limit for hydrocarbons.

Dow Corning is also working in this area but on its own because it wants to have use of the research later. The company is working on polysiloxanes, primarily halogenated polysiloxanes and silanes, both aryl and alkylsilanes. One of its more promising formulations is QF 6-7009, which chemically is diphenyldidodecylsilane. The material, according to Dow Corning, is stable from −25 to 550F and, for shorter periods, up to 700F. Under test by the Air Force, the compound is now commercially available and sells for $30 per pound in gallon quantities. Like many of the other hydraulic fluids, it is also being offered, with different additives, as a high temperature engine lubricant.

Stauffer Chemical Co. is carrying out research on high temperature hydraulic fluids through its Anderson Chemical Co. Division which specializes in the synthesis of organometallic materials based on silicon and boron. At present Anderson has government contracts for work on the alkylsilanes.

Polyphenyl Ethers

Beyond 700F. The most promising hydraulic fluid candidates for use at temperatures above 700F are the polyphenyl ethers. Originally these materials were developed chiefly for their radiation resistance.

Shell Oil Co., General Electric and Monsanto Chemical Co. have been actively exploring the polyphenyl ethers under Air Force contracts while Dow Chemical has been carrying out work on these materials on its own.

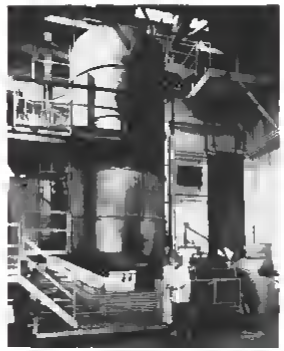
The upper temperature limit for the ethers is presently estimated to be about 900F.

Monsanto is also working on an Air Force contract to develop a hydraulic fluid base stock for service at 1,000F. The company considers the polyphenyl ethers definitely unsatisfactory for operation at this temperature except for very short periods of exposure.

WADC is also looking at some polynuclear aromatics and tetraarylsilane for possible use in this temperature range. The in-house research on the ferrocene derivatives, organosilicon and other organic and inorganic materials is being carried out by the polymer section of the Materials Laboratory. This section is also doing some work on tetra-substituted ureas.

Another possibility that interests the Air Force is the use of liquid metals, the most promising of which is NaK_{77}, the eutectic mixture of 77% potassium and 23% sodium (AW Nov. 11, 1957, p. 69). Corrosiveness, spontaneous ignition and explosive reaction with water are some of the principal disadvantages of the material. The Air Force has a contract with General Electric for the study of liquid metals as power transmission fluids.

Other strong candidates in the 700F. plus range, according to WADC's



Coating for Titanium

Barrier-type ceramic coating prevents contamination of titanium alloy during 1,700F heat treatment in vertical furnace at Boeing Airplane Co. Furnace handles 4x10 ft. 6Al-4V titanium alloy sheet during the 30 min. process. Protective coating, which fuses at 1,450F, has proved effective with titanium and some stainless steels, the aircraft manufacturer reports.

George Baum, are the ferrocene derivatives, complexes of iron and cyclopentadiene. A strong point in their favor is their wide liquid range. WADC is working on these materials, but to date there is still comparatively little data available.

Another authority on the merit of the new hydraulic fluids is Republic Aviation. In its work on the development of a complete hydraulic system for operation at 1,000F, Republic has made a fairly extensive study of the new fluids and has checked some of them out in a hydraulic test rig at its Farmingdale plant. The test rig is basically a miniaturized, high temperature hydraulic system.

One of the most important reasons for the miniaturization, according to Republic, is the high cost of the fluid samples, some of which run as high as $1,000 a quart.

Under terms of the Air Force contract, the operational temperature limits for the Republic program are 20 to 1,000F.

By agreement with WADC, Republic has established as a program goal, based on probable aircraft missions, an operational time of 1½ to 5 hr. at 1,000F. To date, this goal has not been met, says Republic engineer William Mayhew. The most accomplished so far has been 25 hr. at 800F and 1½ hr. at 900F before the hydraulic fluid broke down. Republic has run some tests at 1,000F, but has not yet evaluated the results.

The fluid used in these tests was bis (paraphenoxy) phenyl ether, which was supplied the company by WADC Materials Laboratory. Although short of the 1,000F goal, the temperatures reached are considered a significant advance in the field. The 230F melting point of the material, however, is considered a definite drawback to its use. Republic has done preliminary tests on a rearranged molecular version of the fluid which has a 20F melting point. This is bis(metaphenoxy) phenyl ether, purchased by Republic from Distillation Products Industries Division of Eastman Kodak Co. Results so far indicate that the bis-meta is as good or better than the bis-para material.

Among the other materials Republic has looked at closely are the following:

- **Organometallic compounds**, promising, but much work to be done on individual materials. One organoboron compound, in particular, shows promise, but has poor hydrolytic stability.
- **Ferrocene derivatives**; looks good, but also at a very preliminary stage. A ferrocene derivative that looks particularly promising over the whole 0-1,000F, temperature range is silovanyl ferrocene which also appears to be radiation resistant.
- **NaK**: Tempting because of tem-

perature range, 14F (melting point) to 1,440F (maximum thermal stability point), but poor lubricity, corrosive and hazardous. As a group, liquid metals don't seem to be worth the development effort as opposed to the organic compounds. In fact, some companies are studying different organic-based materials with an eye to replacing liquid metals being used in atomic reactors.

- **Silicones**: Unattractive, short life at 700F and above, poor lubricity, low bulk modulus. At high temperature, silicones absorb and retain air, making them spongy and resulting in flutter conditions in the controls.
- **Silphenylene**: An outgrowth of silicone work, lacks lubricity but merits attention. Republic has obtained a pint sample of the material from General Electric but has held off trying it in its test rig because of poor lubricity.
- **Alkylsilanes**: Look good, but deficient in low temperature properties.
- **Mineral oils**: A few look good. Republic has consulted Drs. Teaske and Klaus at Pennsylvania State University but so far has seen no indication that the petroleum hydrocarbons will do the job that the company wants done.

Some consideration should be given to the possibility Mayhew feels, of blending the different polyaromatics with various polyaromatic ethers in order to lower the melting point of the latter and raise the thermal stability of the former.

Hardware Development

With Phase I of its Air Force contract completed and with the continuation of Phase I scheduled to end next May, Republic is now preparing its proposal for Phase II with which it expects to carry out actual hardware development. The company feels it will be ready to go ahead on hardware development, in the immediate future because of very encouraging results obtained to date with bis (paraphenoxy) phenyl ether and the bis (metaphenoxy) phenyl ether. And while the ultimate low temperature goal is −65F, Mayhew believes that it will be some time before this is achieved and that 20F is the most realistic goal at present, with the possibility of going to zero F in the near future.

It takes about five years from the time a new hydraulic fluid starts development, according to Baum, to qualify it. Two of the five years are spent in just getting a large enough quantity of the material to evaluate.

At WADC, the lubricants section of the Materials Laboratory checks out physical and chemical properties of fluid. Early evaluation does not differentiate between engine lubricants and hydraulic fluids. Working in cooperation with the components industry, the Materials Laboratory may spend one

to two years collecting performance data on how the fluid reacts with such things as seals and valves in mock-up equipment. Then the material may go to the Aircraft and Propulsion Laboratories where it will be evaluated from a systems viewpoint. The Aircraft Laboratory, says Baum, does only simulated systems work. Complete system study will be carried out by the airframe manufacturer.

Of all the materials that start out in the test tube, perhaps only one in a million will eventually qualify as a high temperature hydraulic fluid. But after the fluid reaches the large scale evaluation stage, says Baum, its chances for final acceptance increase to about one out of 25.

At some point along the line the Materials Laboratory will probably have written a test specification for the guidance of researchers working on the different types of fluids. This will eventually be rewritten by the Materials Laboratory to fit the particular fluid that meets most of the target requirements. The Materials Laboratory will then evaluate all succeeding candidates for a particular hydraulic group against the final specification either accepting them or rejecting them for Air Force use or, possibly, even rewriting the final specification to fit a superior candidate.

Fortunately, while there is still a great deal of work on the development of new high-temperature hydraulic fluids, there is also much incentive.

The present market for aircraft hydraulic fluids is estimated to be about 2.3 million gal per year. Almost all the current demand is for Mil-H-5606 petroleum base hydraulic oils. But during the coming year, it is estimated that demand for the first synthetics may run as high as 80,000 gal. And in the opinion of Oronite's McGuire, a continuing growth is anticipated. Monsanto, for example, is confident that all jet aircraft, including transports, will require synthetic hydraulic fluids in the not too distant future.

The synthetic fluids can command an attractive price. Type III synthetic materials will probably cost about 20 times as much as the mineral oils while Type IV fluids may cost twice as much as Type III. Present price tag on Type III fluids is about $20-$25 per gal.

It is a market that the chemical companies believe is worth exploiting. Some companies such as Stauffer say they are interested in supplying only the base stocks for the finished fluids. Others such as Celanese say they would prefer to supply the finished fluid. And some such as Union Carbide which are now supplying base fluid (the diisooctane ester for Oronite's MIL-O-9315) may start marketing finished fluids whenever they find some presently unforeseen advantage in doing so.

WHAT'S NEW

Telling the Market

Construction, operation, electrical ratings, capacities, weights and dimensional drawings on **Rhxon Inherent Overheat Protectors** for single phase a.c. and d.c. and three-phase aircraft electric motors, technical bulletins MOPR 2 and MOPR 11, Metals & Controls Corp., Spencer Division, Attleboro, Mass. . . . **High tensile fastener design considerations**, all relevant NAS and MS bold specifications and tables cross referencing 160,000 psi, 180,000 psi and 220,000 psi bolts and compatible stop nuts. Design Manual No. 5825, Elastic Stop Nut Corporation of America, 2330 Vauxhall Rd., Union, N. J.

State-of-the-art report on **Infratron lead sulfide photoconductors**, Technical Bulletin 2, Infrared Industries, Inc., 163 Highland Ave., Needham Hgts. 94, Mass. . . . Specification drawings and information on **solder terminals**, Catalog 158-Section 1, Alpine Electronic Components, Inc., Waterbury, Conn. . . . Features, applications and specifications of **Digital Indicator and Printer Model 176**, bulletin, Gilmore Industries, Inc., 13015 Woodland Ave., Cleveland 20, Ohio

Specifications, military approval data and applications of **radio interference and field intensity measuring equipments** covering a frequency range of 30 cps to 1,000 mc, five four page bulletins, Stoddard Aircraft Radio Co., Inc., 6644 Santa Monica Blvd., Hollywood 38, Calif. . . . Specifications, application information and dimensional drawings of **indicating and electrical-output pressure and acceleration measuring devices and switches**, pitot-static testers and Mach number calibrators, catalog package, Burton Manufacturing Co., 2520 Colorado Ave., Santa Monica, Calif.

Illustrated booklet outlines the job of a **takeoff monitor** and describes the functions and features of the system, Sales Promotion Dept., Aeronautical Division Minneapolis-Honeywell Regulator Co., 2600 Ridgway Rd., Minneapolis 13, Minn. . . . Description, specifications and drawings of **miniature encapsulated pulse transformers** wound on high permeability ferromagnetic cores, technical bulletin, Technitrol Engineering Co., 1952 East Allegheny Ave., Philadelphia 34, Pa.

Illustrated catalogue outlines the facilities and describes the **equipment and components** manufactured by the Aviation Division, Walter Kidde & Company, Inc., 675 Main St., Belleville 9,

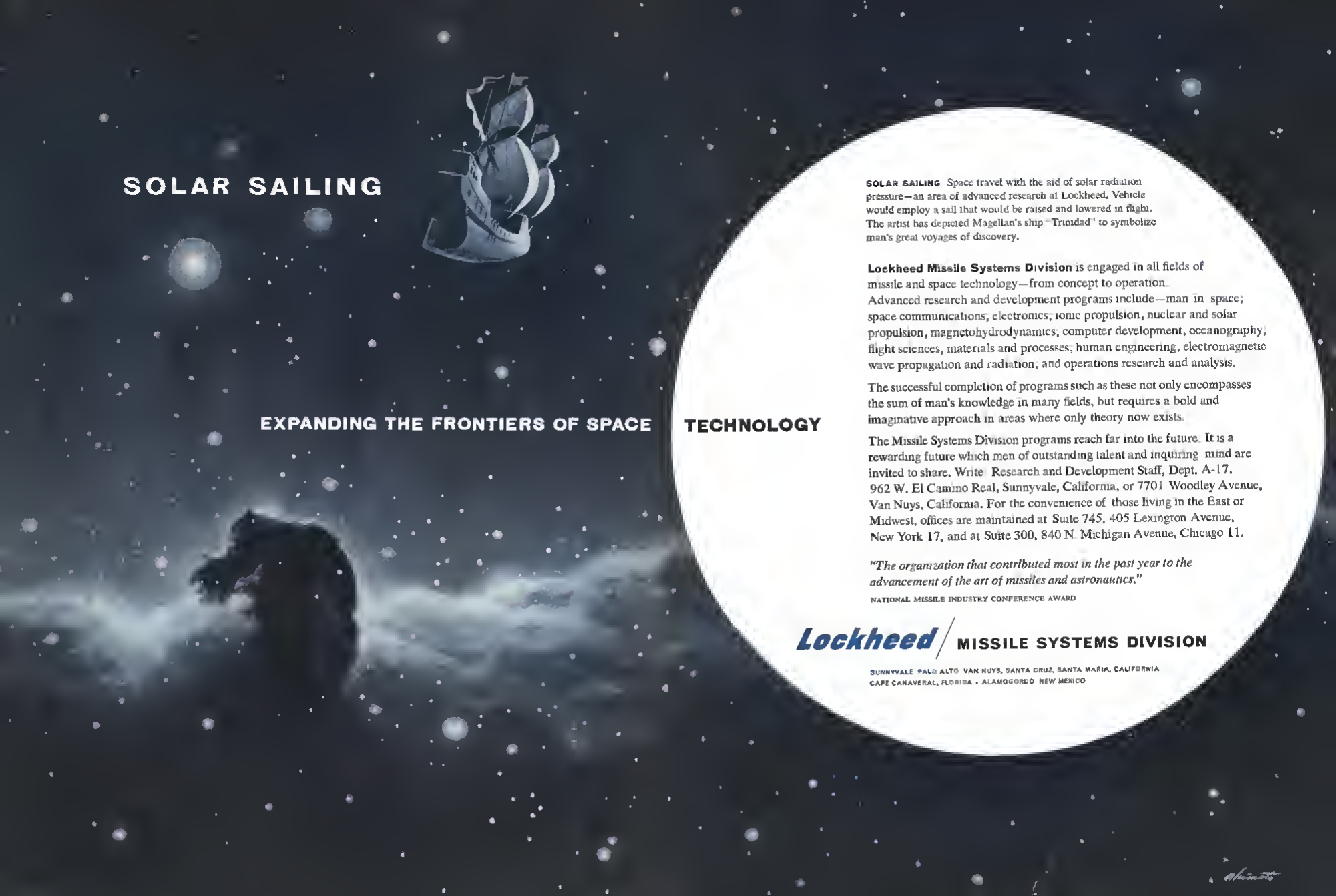
N J ... Characteristics and specifications of American flexible connectors of Teflon, Bulletin No TC 101 The American Brass Co., American Metal Hose Division, Waterbury 20, Conn ... Illustrated design information on a device for shaft analog-to-digital conversion, Brochure DI 03, Data Instruments Division of Telecomputing Corp, 12838 Saticoy St., North Hollywood, Calif

Outline of research and development capabilities in the general field of pyrotechnical devices as applied to incendiary compositions, delays and linear products to produce time delay or convey ignition or detonation brochure, The Ensign-Bickford Co, Simsbury Conn. ... Features applications and specifications of Model C image converter camera, brochure, Applications Engineering, Precision Technology Dept, Librascope Inc, 66 South P St, Livermore, Calif

Bulletin 385A, a Servo Motor bulletin for design engineers, contains applications data, schematics, characteristics and installation drawings, Merchandising, Ketay Dept., Norden Division, United Aircraft Corp Commack L I, N Y ... Control Applications for Polarized Relays, bulletin P 7279 I Barber Colman Co, Electrical Components Division, Rockford, Ill. ... Description, tolerance curves and characteristics of flow-control servo valves, Catalog 220, Moog Valve Co, Inc, Proner Airport, East Aurora, N Y

Photographs, air-flow pressure drop curves operating description, cross section drawings and specification tables of 40-micron breather filters, Engineering Data Sheet No. 101, Bendix Filter Division, Bendix Aviation Corp, 434 West 12 Mile Rd, Madison Hgts, Mich ... Outline of the test and calibration facilities for the manufacture of precision potentiometers, Technology Instrument Corporation of California, 7229 Atoll Ave, North Hollywood

Illustrated Gyro Primer explains how gyros work, gyro terms and gyro operating principles., Ketay Department, Norden Division, United Aircraft Corp, Commack, N Y ... 1958-59 General Electric Sealed Relay Catalog features engineering information on microminiature relays, etc, Schweber Electronics, 60 Herricks Rd, Mineola, N Y Illustrated filter engineering and application reference manual contains specifications, flow curves, capacities and sizes, exploded views and cross-section drawings, hydrocarbon viscosity tables and a viscosity conversion chart, Bendix Filter Division, Bendix Aviation Corp, 434 West 12 Mile Rd, Madison Hgts, Mich



SOLAR SAILING Space travel with the aid of solar radiation pressure—an area of advanced research at Lockheed. Vehicle would employ a sail that would be raised and lowered in flight. The artist has depicted Magellan's ship "Trinidad" to symbolize man's great voyages of discovery.

Lockheed Missile Systems Division is engaged in all fields of missile and space technology—from concept to operation. Advanced research and development programs include—man in space; space communications, electronics; ionic propulsion, nuclear and solar propulsion, magnetohydrodynamics, computer development, oceanography; flight sciences, materials and processes; human engineering, electromagnetic wave propagation and radiation, and operations research and analysis.

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WHO'S WHERE

(Continued from page 15)

Changes

A. P. Albrecht, general manager, Space Electronics Corp., Glendale, Calif. Also, R. W. Williams, manager, launch control department; A. W. Newberry, manager, instrumentation department; R. W. Sanders, manager, analysis department; W. A. Makofske and R. M. Stewart, senior members of the technical staff.

Richard B. Fuller, director of purchases, Stanley Aviation Corp., Denver, Colo.

Lockheed Aircraft's Georgia Division, Marietta, Ga., has established a new Reliability Branch, incorporating the Quality Control, Flight Operations and Field Service Departments, and has named Gordon Thorn, director of reliability.

Norton C. Joerg, European representative (London, England) Link Aviation Inc., Binghamton, N. Y.

William G. Evans, general purchasing agent, Convair Division of General Dynamics Corp., San Diego, Calif. Also, W. Robert Bruce, chief subcontract, Lou F. Tubbs, Jr., purchasing agent, high value items.

Eddie Holohan, assistant to the executive vice president, The Flying Tiger Line.

Don R. Proctor, chief engineer, Electronic Engineering Company of California, Santa Ana, Calif.

Carl J. Tylka, director of technical service, Cooper Alloy Corp., Hillside, N. J.

Sumner L. Barlan, director of equipment sales, Inland Testing Laboratories, a division of Cook Electric Co., Morton Grove, Ill.

Edmund A. Schreiber, purchasing agent, Helipot Division of Beckman Instruments, Inc., Fullerton, Calif.

Charles E. Rowell, assistant director, sales and service, Telpar Pioneer Division of Bendix Aviation Corp., Teterboro, N. J. Also, Eugene Foxworthy, sales manager, systems, Edward J. Petterson, sales manager, instruments and components.

William L. Siy, Eastern Division sales manager, Air Marine Motors, Inc., Amityville, N. Y.

Dr. Ralph A. Schaefer, director of the newly established research and development department, The Bunting Brass and Bronze Co., Toledo, Ohio.

Anthony C. Hummel, Dayton, Ohio, technical service representative, Defense Products Department, Callery Chemical Co., Pittsburgh, Pa.

Alvin E. Weill, director, laboratory services, C. P. Clare & Co., Chicago, Ill.

William F. Arnelt, manager, Research Administration Department, Allen B. Du Mont Laboratories, Inc., Clifton, N. J.

Howard L. Jennings, Washington, D. C., sales representative, AC Spark Plug Division of General Motors, Milwaukee, Wis.

William H. Mahler, supervisor, transportation market, New York Sales Division, Gulf Oil Corp., New York, N. Y.

J. L. Reddan, district manager of the newly established San Diego, Calif., sales engineering office, Aviation Division, Waller Kidde & Company, Inc., Belleville, N. J.

George K. Johnson, assistant manager, Lockheed Missile Systems Division plant, Van Nuys, Calif.

Sperry Develops High Density Gyro Fluid

By Michael Yaffee

New York—High density of the new bromotrifluoroethylene gyro damping fluid used in Sperry Gyroscope's inertial guidance package for the North American X-15 now appears to be an even more important characteristic to many engineers than material's low temperature fluidity (AW Dec 29, p 25)

Developed in an extension of the work on chlorotrifluoroethylene oils which have been used as flotation fluids in earlier inertial systems, bromotrifluoroethylene has a density of 2.45 gms/cm³, as compared to maximum density of 1.92 gms/cm³ for the chlorocompounds. This increased density is expected to prove particularly important in missile guidance systems where size and weight are more critical than in manned aircraft.

With its greater density, bromotrifluoroethylene will enable guidance manufacturers to float a heavier mass in the same size package or the same mass in a smaller package. The basic aim, of course, is to reduce both weight and size of the complete inertial guidance system. The inertial guidance system developed by American Bosch Arma Corp. for the Martin Titan, for example, was believed to weigh almost 500 lb. originally (AW May 12, p. 92).

With a new digital computer and gyro stabilized platform, Arma hoped to cut the weight in half. Even this, however, would still leave the total weight considerably higher than desired for newer systems, such as the one now under development for the Lockheed Polaris. It is reported that Massachusetts Institute of Technology scientists are trying to keep the weight of the Polaris guidance package to approximately 70 lb. and that an important part of this weight reduction program will be the use of high density damping fluids based on bromotrifluoroethylene.

At present, straight bromotrifluoroethylene suitable for use as a damping fluid is an expensive material, costing about $700/lb. in small laboratory quantities. With the development of a market as small even as 100 lb. per month, it is expected that this price will drop to $150-$250/lb.

In applications currently under development, however, the material is not being used in pure form. The formulation developed by Sperry chemists is a mixture of bromotrifluoroethylene, chlorotrifluoroethylene and a thickening agent. A somewhat similar formulation was also developed by Halocarbon Products Corp., Hackensack, N. J., which is currently the only major producer of the base bromofluid. Currently, Halocarbon Products is supplying high density bromotrifluoroethylene oils to Massachusetts Institute of Technology for experimental purposes and is expected to supply Sperry with its special formulation as soon as Halocarbon can put it into production.

Other producers of the parent chlorotrifluoroethylene materials and potential suppliers of the bromotrifluoroethylene fluids are Minnesota Mining and Manufacturing Co. and Hooker Chemical Corp.

Meanwhile, the chlorotrifluoroethylene polymers, originally developed for the Manhattan Project during World War II, are finding increasing uses as lubricants and protective coatings in liquid oxygen and other oxidizer equipments on the ground and in the air.

The proneness of certain organic materials to detonation after contact with liquid oxygen creates a problem in obtaining lubricants suitable for use in liquid oxygen pumps, compressors, etc. There also is the problem of oxygen spillage at missile launching sites which would become even more critical if missiles go underground in a manner envisioned for the Titan. For a solution to these problems engineers have been turning to chlorotrifluoroethylene oils and greases which offer a high degree of chemical inertness and thermal stability as well as good lubricity at low temperature, high dielectric strength, high density and non polar characteristics.

At present, chlorotrifluoroethylene materials are being used by Atlantic Missile Test Range supervisor Pan American World Airways in most of its liquid oxygen handling equipment at Cape Canaveral, Fla., and by the Martin Co. in its ground support equipment for both the Vanguard and the Titan. The material also is designated for the Clark Equipment Co. compressor which is used to compress the inert gases which pressurize the liquid oxidizer in the Boeing Bomarc booster. Here, the use of the inert halocarbon prevents hydrocarbon contamination and ensures that there will be no flammable or explosive oils carried over into the reactive oxidizer.

HIGH density fluid (left) remains in liquid state at 15 deg. below operating temperature, earlier damping medium solidifies

For the same reason, chlorotrifluoroethylene lubricants are slated for use in the metering pump in the first X-15 engine, which is expected to use a liquid ammonia oxidizer with a JP fuel (AW Oct. 20, p. 29), as well as in later models which will use liquid oxygen.

The halocarbon oils also display high stability and inertness in the presence of red fuming nitric acid and 90% hydrogen peroxide and have been used in equipment which handles these oxidizers. One area where these fluoro compounds are less successful is with liquid fluorine oxidizers. Jet Propulsion Laboratory was interested in trying the material on pumps for chlorinetrifluoride, and Halocarbon Products has been supplying the material to Bell Aircraft Co. But Halocarbon President Dr. Robert Ehrenfeld is convinced that chlorotrifluoroethylene won't work and might present a hazard in case of contact with any liquid fluorine compound.

In another recent development, Halocarbon Products has formulated an aerosol preservative which consists of a chlorotrifluoroethylene wax mixed with zinc chromate and dissolved in an aerosol. This material is aimed primarily at equipment in storage and the first shipment of aerosol cans is on its way to Martin's Titan team at Cape Canaveral.

To prevent equipment from rusting in storage it usually is given a heavy coating of grease. Then especially when the equipment is destined for use with liquid oxygen, it must be chemically cleaned and this often means it must be almost completely disassembled. The use of the chlorotrifluoroethylene aerosol, Dr. Ehrenfeld says, is expected to do away with the need for dismantling the equipment and should speed the process considerably. In case of a scratch or imperfection in the coating, the zinc chromate is designed to act as a rust preventive.

Compared to the anticipated price of $150-$250/lb. for the bromofluoroethylene damping fluids, chlorotrifluoroethylene damping fluids cost $35-$45/lb. Because the specifications governing the lubricants and preservatives are much less stringent, chlorotrifluoroethylene oils and waxes cost only $12-$15/lb.

USAF-Convair's Atlas 10 B is shown on its launch pad at Cape Canaveral, Fla., before it was launched into orbit. Lifetime now is estimated at 45 days. Missile carries Army Radio Corp. of America voice teletype communications relay, and is designated Project Score for Signal Communications by Orbiting Relay Equipment (AW Dec. 29, p. 18). At right, the Atlas 10 B is reflected in the water trough running from the launch pad's flame bucket.

Atlas Readied for Successful Launch into Orbit

Atlas satellite carried a recording of President Eisenhower's voice, project was executed for Advanced Research Projects Agency by USAF Ballistic Missile Division and Army Signal Corps. At left, technicians make a final pre-launch check. Atlas 10 B is launched into space at right at 6:02 a.m., Dec. 18. General Electric Burroughs radio inertial system guided Atlas into orbit. Apogee is 928 mi., perigee 114.5 mi.

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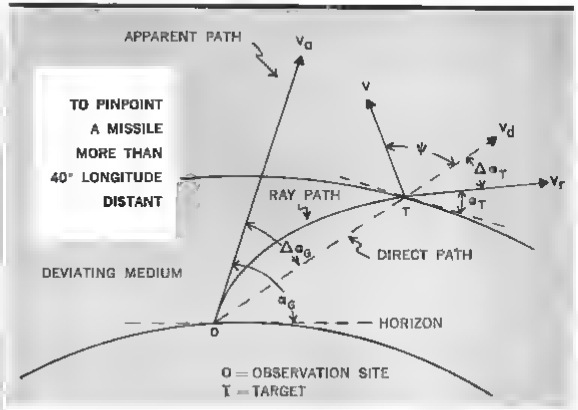

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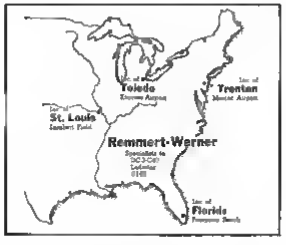

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EXCITING NEWS in BUSINESS AIRCRAFT

See Page 93

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AVIATION WEEK, JANUARY 5, 1959

CLASSIFIED ADVERTISING
F. J. Eberle, Business Mgr.

ADVERTISERS INDEX

LETTERS

Constructive Criticism

In the past I have always looked forward to the enjoyment of reading the editorial by Mr Hotz in each AVIATION WEEK although I have not always agreed with him entirely The enjoyment comes from the fact that he discusses timely and interesting subjects with a directness and fearlessness which is truly commendable

I find it my duty however, to object violently to a statement he made in the Dec 8 issue regarding the Navy's past strategic role as having "... devoted a major portion of their efforts to impinge on the primary USAF mission of long range megaton bomb delivery" On the contrary, I believe Mr Hotz will find that the Navy has devoted the major portion of these efforts and funds towards the development of weapons delivery techniques which the USAF is incapable of performing in their B-47s and B-52s

In this manner the Navy has averted a "... primary reliance on the Air Force as a 'dynamic deterrent' ..." Furthermore, this is a situation which would not have been possible had not some of the naval leaders 'organized and led inter service attacks' to keep from being engulfed by the glamor and glory of the Air Force concept of the big bombers

In closing I only wish to say to Mr Hotz, your constructive criticism is outstanding and many of us have devoted our most productive years towards protecting your right to make these criticisms but please, don't ever sell your Navy short

B H ASHLEY
Lt, USN
Boulder, Colo

Withheld Information

Estimates on the capability of our Strategic Air Command to retaliate in the event of an enemy attack are very impressive It may be a great matter of pride to the military to know that if 100 American cities are annihilated that within hours we will destroy 100 enemy cities Personally, I take no pleasure in such a trade There may be survivors Unless an effort is made to save them direct them, perhaps even set now so that there may be more survivors the conditions of such survival may be of doubtful duration and limited value

Withheld information has practically killed the Civil Defense The people are apathetic Two attitudes prevail The most prevalent one seems to be, It can't happen here

The other is, "I can't do anything about it anyway" Neither attitude is healthy or American Why aren't the millions of people interested in avoiding conditions of unknown horror? In my opinion they don't know what to expect, what to attempt to do about it, what the real probabilities are The general idea is that a hydrogen bomb is effective for 10 mi, 20 or possibly 25, and therefore if one lives 26 mi. from City Hall he is immune and there is no problem

Will you please publish what Russia can do, the probable size of missile warheads in megatons probable accuracy, possible numbers range and the radius of effect? Will you, in a kindly manner of course, tell us what we are in for and let the people know that the target areas may be small but that the probable strike area is large, and that fallout as well as sudden destruction can happen anywhere? Your efforts in AVIATION WEEK to wake up Congress and the defense administrators has at least awakened many engineers and technicians I believe that you have better solutions to the problem than concrete burial vaults or mass flight The problems, the solutions and your suggestions on how to create an effort would make an issue of such value to the public that it could change history Who else has the information or the courage to present it?

PAUL L SANFORD
Anaheim, Calif

Aviation Week welcomes the opinions of its readers on the issues raised in the magazine's editorial columns. Address letters to the Editor, Aviation Week, 330 W. 42nd St., New York 36, N. Y. Try to keep letters under 500 words and give a genuine identification. We will not print anonymous letters, but names of writers will be withheld on request.

Emphasize Winds

I think Mr Hayes' description of what can happen in a wind shift is accurate (AW Nov 17, p 134) I crashed in April 1955, at Vincent, Calif when piloting a Luscombe into the shear of the cold coastal air and the warmer desert air There was a transition from smooth air to extreme turbulence and loss of control in less than a minute It seems there should be more emphasis placed on these situations when training pilots Pilots who are confused with downwind turns and wind shifts might review the equation force equals mass times acceleration

DON LLEWELLYN
Ex Pilot
Burbank, Calif

P S I now sit on the ground and fly radio-controlled model airplanes

Transitory Stall

I have reviewed Mr Hayes' letter (AW Nov 17, p 134) and it appears that he is as capable of a 180 deg switch as the wind shift we have been discussing I am happy to read that he now considers my remarks (AW Oct 6 p 114) obvious," but this is a far cry from his earlier statement (AW Sept 8, p 118)

In his letter of Sept 8 he wrote "... an approach which is ahead at an angle of attack just below the stall, suddenly encountering an increase in headwind can also increase the angle of attack ..." It was this fundamentally erroneous postulation that prompted my comment concerning the decreasing angle of attack in such circumstances

The Nov 17 half-column of gobbledygook about, 'turbulence at the shear level' Dynamic unbalance ... rotating the nose faster, and higher ..., etc., etc., etc changes this truth not one iota All this moon can be summed up with another "obvious" remark though an may cause a transitory stall particularly if the aircraft under consideration is flying at a high angle of attack.

No argument with this, but we seem to have digressed somewhat from the original point

As for Mr Hayes' view that the effects of vectorial addition (of the wind gradient) are necessarily 'puny' compared to the effects of turbulence, I can only wish him good luck He may need it

GRAHAM THOMSON
Santa Barbara Calif.

Better Search Gear

In a letter titled "ASW Craft" AVIATION WEEK, Nov 3 (p 110) it is proposed to replace the helicopter with a surface vessel of equal speed maneuverability etc. A fine idea but it can't be done The chief advantage of the helicopter is that the submarine cannot tell which direction it will "ping" from next because it is able to completely divorce itself from the surface of the water and move to a new location in the same contact area A surface vessel on the other hand is easily tracked by the submarine and the captain then can discern the direction of the attacking vessel and take proper evasive action

The big need in ASW is better search gear

Once localized you have a 50 50 chance of beating your foe but the big problem is finding him in the first place

ROBERT FARRELL
Wheaton, Ill

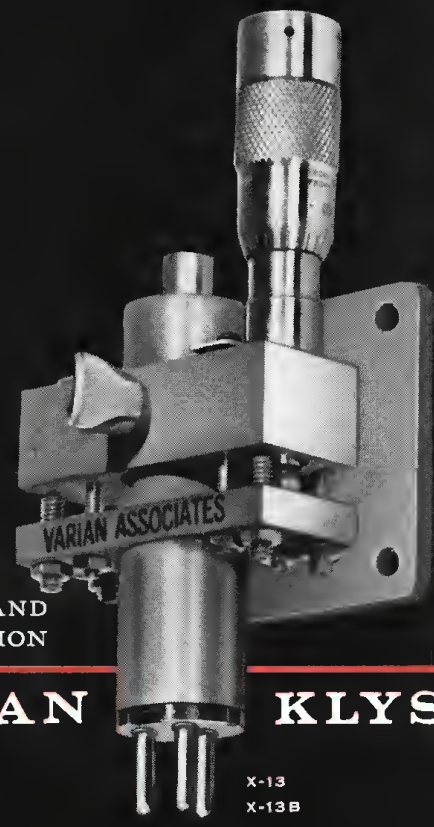
Jet Fares

Ford Eastman's article "Plan Sought to Avert Used-Plane Surplus," AVIATION WEEK Nov 3 (p 42), was very interesting and bears more on the future than a lot of us care to admit

I offer that an increased "specialty" fare for jet flights would both serve the purpose of avoiding dumping of piston planes on the market and assist in the financing of new equipment The dollar returns of this plan are clearly visible It would slow up the release of piston planes due to airlines offering lower (or present) fares to piston users thus being a buffer against themselves incurring possible bankruptcy losses during the changeover time of heavy competition at same fares when airlines with jet equipment two years ahead of others, can inflict heavy damage This slower release of piston planes would also tend to stabilize their lessening market value at a "recuperable" rate rather than to dump the piston value all at once

Any stabilization of fares to be the same on jets as pistons will tend to make an economic catastrophe in forcing marginal or newer carriers to "have jets or else" The repercussions of this will be felt for years in the industry and on Main Street

W C HELLER
Flourtown, Pa



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